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EDITORIAL NOTES.

THE Mines Department announces the formation of an Advisory Committee to assist the Secretary for Mines in matters relating to the Metalliferous Mining Industry. Never was the mining of metalliferous ores in this country in a more parlous condition, for, with the exception of iron ore and ironstone mining and quarrying, practically all the metal mines of the country are shut down, for the very good reason that the cost of production of the dressed minerals is higher than the price at which they can be sold. The high price of production is to be ascribed partly to the increased cost of labour, partly to the high price of materials; while the low price offered for the products is due partly to the low level at which the metals stand in the markets of the world (they are down in some cases nearly to pre-war level), and partly to the high returning charges of the smelters, whose costs have been heavily increased both by the high price of labour and the excessive cost of fuel. Mr. Bridgeman is to be congratulated on being able to get together such a representative body to advise the Mines Department. Its constitution is as follows:—

Sir Cecil Lindsay Budd, K.B.E.	Chairman.
Brig.-Gen. G. M. Jackson Mr. Myles Kennedy, J.P. Mr. S. J. Lloyd, J.P. Mr. Claud Edward Pease, J.P.	Representatives of owners of Iron Ore Mines and Quarries.
Mr. Harry Dack, J.P. Mr. T. Gavan-Duffy Mr. William Lewney, J.P. Mr. Will Sherwood	Representatives of workers in or about Iron Ore Mines and Quarries.
Mr. R. Arthur Thomas	Representing Owners of Tin Mines.
Mr. Joseph Harris	Representing workers in or about Tin Mines.
Mr. Anthony Wilson, J.P.	Representing owners of Lead and Zinc Mines.
Mr. James Wignall, M.P.	Representing workers in or about Lead and Zinc Mines.
Mr. Thomas Falcon Mr. Frederick H. Hatch, O.B.E., Ph.D. Mr. Frank Merricks, C.B.E.	Mining Engineers.
Mr. Frank William Harbord, C.B.E.	Metallurgist.
Mr. T. C. F. Hall Professor Henry Louis, D.Sc. Dr. James Malcolm Maclaren	Economic Geologists.

Mr. J. J. Burton	Representing the Iron and Steel Industry.
Sir Kenneth Weldon Goadby, K.B.E.	Representing Medical Science.

Mr. F. C. Starling, of the Mines Department, will act as Secretary to the Committee.

The Chairman, Sir Cecil Budd, is well known as the Chairman of the British Metal Corporation and of the London Metal Exchange, and as an authority on the non-ferrous metals generally. Of the representatives of owners of ironstone mines and quarries General Jackson is interested in the iron mines of Cumberland, Mr. Myles Kennedy in those of Lancashire, and Mr. Claud Pease in those of the Cleveland district; while Mr. Lloyd owns ironstone quarries in Northamptonshire, Mr. Thomas represents the owners of tin mines and Mr. Anthony Wilson the owners of lead and zinc mines. Of the representatives of the workers Mr. Harry Dack represents the Cleveland miners, Mr. Gavan Duffy those of Cumberland, Mr. Lewney those of Lancashire, Mr. Sherwood the ironstone quarrymen, Mr. Harris the tin miners, and Mr. Wignall the lead and zinc miners. Economic Geology is well represented on the Committee, Mr. Hall being especially acquainted with the geology of the lead and zinc mines of Shropshire, Dr. Maclaren with the tin mines of Cornwall, and Professor Louis with the iron mines; Dr. Hatch, although he appears among the mining engineers, is also not unknown as an economic geologist. The other mining engineers are Mr. Merricks and Mr. Falcon; while Mr. Harbord represents metallurgy. Mr. Burton, of Middlesbrough, will advise on the iron and steel industry generally, and Sir Kenneth Goadby on the medical aspects of mining. The Committee will hold its first meeting on 5th July.

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The Imperial Mineral Resources Bureau continues to issue at intervals its "monographs", or, to give them their proper title, "Digests of statistical and technical information relative to the production and consumption of the metals and useful minerals." Up to the present fifteen have appeared, namely, those on aluminium and bauxite, antimony, arsenic, asbestos, bismuth, borates, chrome ore and chromium, cobalt, felspar, Fuller's Earth, magnesite, manganese, monazite, nitrates, and zinc. One on tungsten will be published shortly and others are in an advanced state of preparation. These include some important monographs, for instance, those dealing with iron, coal, and copper. That on iron will be entitled "The Iron Ore Resources of the World", and will be practically on the lines of, but bringing up to date, the report of the Geological Congress which met at Stockholm in 1910. Special funds for the purpose have been contributed by the National Federation of Iron and Steel Manufacturers.

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Meantime the figures for the world's production of minerals for the years 1914–18 have for the bulk of the minerals not yet been published, and similar figures for the years 1919 and 1920 are becoming due. These statistics used to be published by the Home Office, in Part IV of the Report of the Chief Inspector of Mines. During the war their publication was suspended, and on the formation of the Bureau the duty of compiling and publishing them was delegated to the new body. We cannot help thinking that it would have been wiser to have got out as rapidly as possible these vital statistics, and to have left the less important, but interesting, letterpress of the monographs for a more leisurely procedure. Mining engineers all the world over would have welcomed the publication of the production figures, and would have been content to wait until the staff of the Bureau should have had time to cope with the compilation of the monographs.

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The fourth report of the Conjoint Board of Scientific Societies shows that the Board has received evidence that scientific investigation is being seriously hampered by the heavy cost involved in the publication of results. An exceptional number of papers are being communicated to the Scientific Societies, including many held up during the war, while the resources of the Societies, which have not increased, are insufficient at present prices to publish even the normal pre-war number. The country is thus in danger of being seriously handicapped at a time when the rehabilitation of industry is in most serious need of scientific assistance. Much of the report is occupied with a short abstract of the third report of the committee on the water power of the Empire. It is shown that too little is being done to ascertain the total resources, or to secure uniformity in investigation and record. It is urged that steps should be taken to convene an Imperial Water Power Conference in London, at which the various Dominions and Dependencies of the Empire should be represented. The outcome of such a conference might well be the creation of an Imperial Water Power Board, with extensive powers to carry out a comprehensive policy for stimulating, co-ordinating, and, where necessary, assisting development throughout the Empire. The Board has also dealt with questions relating to the formation of National Research Committees, in connexion with the International Research Council, formed in 1919, with the collection of scientific data in the former German colonies, and with instruction in technical optics. The research on glues and other adhesives initiated by the Board as a war measure, at the instance of the Air Ministry, has now been taken over by the Department of Scientific and Industrial Research.

ORIGINAL ARTICLES.

An Eminent Living American Geologist and Palaeontologist.—Professor John M. Clarke,

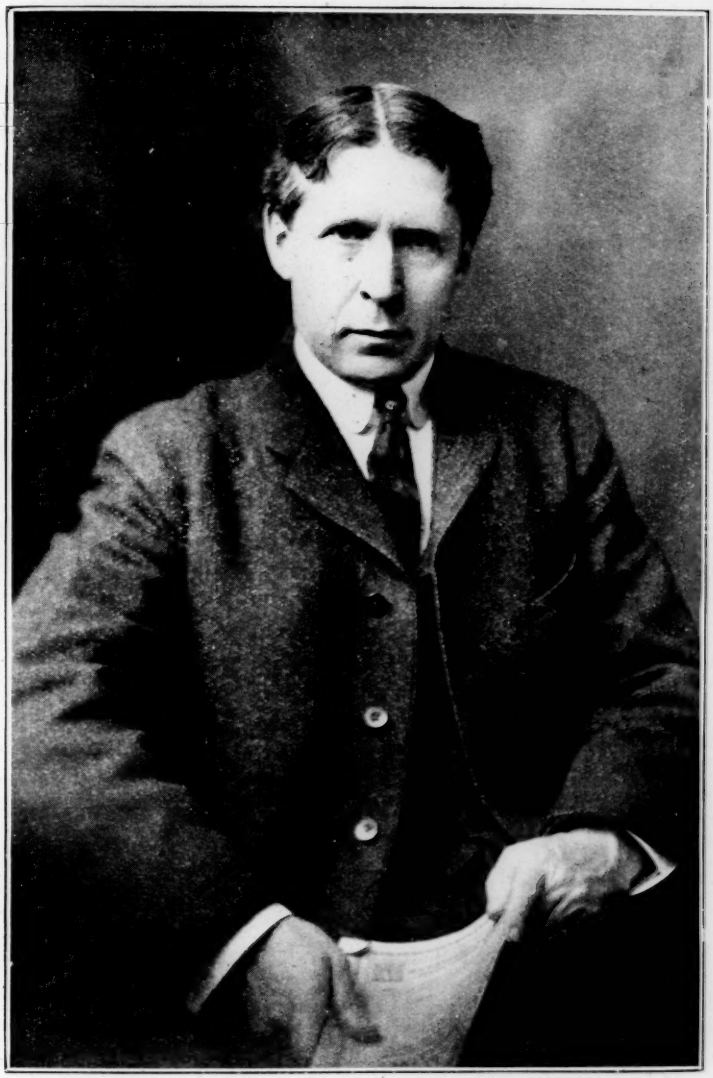
LL.D., D.Sc., For. Corr. Geol. Soc. Lond., Director of the New York State Museum, Albany (New York), U.S.A.

WITH A PORTRAIT (PLATE V).

THE State of New York has long been famous as the centre from which radiated out geological life and energy to the early explorers, whose followers are now to be found spread over the vast States of America. The names of Emmons, Silliman, Dana, and Hall, and a host of other great geologists, may be cited, whose records will never die, and whose work is now being carried on by their living representatives. Such a surviving successor of James Hall now worthily fills his chair at the Albany Museum.

Professor John M. Clarke was born in 1857 in the Puritan village of Canandaigua, in the "Finger Lakes Region" of Western New York State, amid the rich Devonian fossiliferous rocks. Mr. Clarke's boyish desires naturally turned to the study of his native rocks and fossils. His home life was simple and well influenced, his father being for nearly two generations the principal of the Academy, and both father and mother were of the Puritan stock which came out from Old England to Massachusetts in the first half of the seventeenth century. After school and college days, Mr. Clarke became a teacher of geology, first at Amherst College, from which he had graduated; afterwards at Smith College, and this active interest in imparting knowledge he has retained to this day as professor of geology in the Rensselaer Polytechnic Institute, with which he has been associated for more than twenty-five years, in succession to Amos Eaton, Ebenezer Emmons, and James Hall. As a mature student of geological science, Mr. Clarke spent three years at Göttingen, and on his return from Europe he joined on 2nd January, 1886, the staff of Professor James Hall, the distinguished palæontologist and geologist at Albany, where he has remained ever since, in the geological service of the State of New York.

At the time of Mr. Clarke's advent at Albany, James Hall was 75 years old, and while his vigor and enthusiams were unimpaired and his devotion to his great work, the *Palæontology of New York*, unstinted, the extensive researches necessary to carry this work forward naturally fell on younger men. Hall was then in the midst of his greatest productiveness, but his assistant, the late Charles E. Beecher, was leaving and soon the labour of the preparation of these great volumes in all their extensive details of research, drawing, lithography, and printing fell to Clarke, his new assistant. The volume on the Devonian Trilobites and other Crustacea (vol. vii), and the two volumes on the Genera of the Palæozoic Brachiopoda (vols. viii, parts i and ii), were prepared by Mr. Clarke, the latter with the help of illuminating suggestions from Charles Schuchert. But all this work of the assistant, though usually not seen by Professor Hall until in type, was carefully read, annotated, and generously accepted by him



John M. Clarke

[To face p. 292.]

For twelve years this intimate association with Hall continued—until his death in 1898 at the age of 87; and the longer it grew the more the various responsibilities of the work of the State Geological Survey fell upon the shoulders of the younger man. Though Hall believed that the *Palæontology of New York* would die with him, he taught his associate to plan his work on broad and comprehensive lines, a lesson which was interestingly emphasized by the publication a few months after his death of the most impressive of all his volumes, the great monograph of the Devonian Hexactinellid Sponges, which appeared jointly over the names of the master and his assistant. On the death of Hall, Mr. Clarke was made State Palæontologist, and six years later, under a reorganization of the State Education Department and the University of the State of New York, he was installed as State Geologist and Palæontologist, which positions involved also the Directorship of the State Museum and the Department of Science of the University. These responsibilities have continued since 1904. During this period the study of the older rocks of the State of New York and the exposition of its extraordinary postglacial history have gone on with activity and the necessary publications, with the help of a strong body of skilled men, have grown to the number of several hundred. New York is a State covering 4,500 square miles, and its rock geology extends from the Precambrian complex of the Adirondack Mountains and the lower Hudson Valley to a fringe of Cretaceous and Tertiary along the marine shore of Long Island, all between being the Palæozoic plateau in which the faunas of the Cambrian, Ordovician, Silurian, and Devonian are extraordinarily rich and well preserved. Nearly one-half the area of the State is built on the Devonian and this is the formation and fauna that have called forth Mr. Clarke's special labours. As a general consequence of the progress of the survey work, the great geological map of New York State on a scale of one mile to the inch, has been somewhat more than half completed in careful detail.

Mr. Clarke's active interest in the study of the Palæozoic rocks has extended beyond the confines of his State, and he has published quarto volumes on the Devonian geology and palæontology of the Gaspé Peninsula of Lower Quebec, New Brunswick, and Maine. Invited by the late Orville A. Derby, F.G.S., to participate in the geological work of Brazil, he has prepared papers on the Palæozoic faunas of the Amazonas and a quarto memoir, the only one thus far issued by the present Federal Survey of Brazil, on the Devonian of the State of Sao Paulo.

Among the requirements of administrative work, the creation of a new State Museum has been of foremost importance. This is a purely scientific museum, devoted to the exemplification of the Natural History of New York State only, and is very effective in the character of its exhibits, but the installation of this extensive museum in its new quarters in the Education Building has not interfered with the progress of scientific research. Among the lines

of investigation that he has pursued for some years is the geological beginnings of symbiosis and parasitism, and he has now in press a work on the Origin of Dependent Life and the Significance of Disease, a treatise based essentially on palæontological data.

Mr. Clarke has been president of the Geologial Society of America and of the Palæontological Society. He was Chairman of the War Committee on Geology under the first organization of the National Research Council, and is Chairman of the Geology and Palæontology Section of the National Academy of Sciences. He has received the degree of LL.D. from Amherst and Johns Hopkins, and D.Sc. from Princeton, Chicago, and Colgate. He has also received the award of the Hayden Gold Medal of the Philadelphia Academy of Natural Sciences and the Spindiaroff prize of the International Geological Congress. Outside of his own proper branches of science he has concerned himself actively in the conservation of the native birds, and the native flora, and for aid rendered in protection of the wild-fowl colonies of the Gulf of St. Lawrence has received the rare gold medal of the Wild Life Permanent Protection Fund. A township in Gaspé, where he has spent many seasons of scientific work, has been named for him by the Quebec Board of Geographic Names.

Mr. Clarke is a member and officer in a good many societies, scientific and historical, and among others is a corresponding member of the Geological Society of London. He has been for several years President of the Albany Burns Club, one of the oldest literary clubs in America, and is now President of the venerable Albany Institute and Historical and Art Society (founded 1791).

Space will not permit us to add a list of titles of all Professor J. M. Clarke's publications, but we desire to refer to some of the more important :—

1. *Palæontology of New York*, vol. vii (with James Hall): "Trilobites and other Crustacea of the Devonian of New York." 1888.
2. *Palæontology of New York*, vol. viii, pts. i, ii (with James Hall): "Introduction to the study of the genera of Palæozoic Brachiopoda. 1894.
3. *Handbook of the Brachiopoda* (with J. Hall), 2 vols. 1894. 8vo.
4. *The Palæozoic Reticulate Sponges—constituting the family Dictyospongidæ* (with J. Hall). 1898.

   [*Note.*—Nos. 1–4, these were all written by J. M. Clarke.]
5. *The "Naples" (Upper Devonian) Fauna in Western New York.* 1904.
6. *Early Devonic of New York and Eastern North America*, 2 vols. 1909.
7. *Fossus Devonianes du Parana.* 1903.
8. *"Guelph" Formation and Fauna of New York State* (with R. Ruedemann. 1903.
9. In 1912 Clarke, assisted by Dr. Rudolph Ruedemann, issued two grand volumes from the State Museum, Albany, entitled Memoir 14, *The Eurypterida of New York* (one volume of text pp. 440 quarto, with 121 text-figures, and one volume of 88 plates and pp. 441–628 of explanation of plates (with a full index). It is delightful to find in these volumes such a grand collection of new material relating to the American Merostomata all carefully studied and described, together with copious foreign literature relating to the order.[1]—H.W.

   (Except No. 3 all the quarto publications.)

[1] See GEOL. MAG., 1913, pp. 293–300.

Note on the Sequence across Central Spitsbergen from Advent Bay to Agardhs Bay.

By J. W. Gregory, F.R.S.

THE collections described by Mr. Spath were made during Sir Martin Conway's Expedition across Spitsbergen in 1896, and include also those then collected by Professor Garwood and presented by him to the British Museum of Natural History.

The Mesozoic fossils were mainly obtained between Ice Fjord and Agardhs Bay, and especially along the Sassendal where the Triassic beds are well developed. The general relations are clearly shown in the northern side of that valley; the block at the western end is composed of Carboniferous rocks, which dip gently eastward and disappear under the black shales and flags of the Trias.

Our route lay along the southern side of the Sassendal, where at the western end, between Waterfall Camp and the shore of Ice Fjord, a conspicuous platform of Carboniferous rocks projects from the base of the escarpment. The Carboniferous rocks are represented by Productus Limestone in the two cliffs along the shore; and further west, near Waterfall Camp, by cherts and coral limestone.

The Carboniferous beds are covered by the Trias with a slight unconformity between them; this was recognized by direct measurement at the angle between Sassendal and Fulmar Valley, where the Carboniferous beds dip 4° to south-south-west, and the Trias 2° to south-east. The general Triassic sequence is well exposed along the escarpment on the southern side of the valley, as in Sticky Keep to the west, and in the Trident to the east of the valley leading up to Brent Pass. The general succession in descending order may be summarized as follows:—

Section I.		*Approximate thickness in feet.*
G.	Plateau Flags: yellowish, unfossiliferous shaly flags	400
F.	Upper Nodule bed.	
E.	Oozy Mound beds: thin dark grey to black shales with phosphatic nodules. Fossils in three seams.	
	(3) Upper seam—Belemnites.	400
	(2) Middle seam—*Daonella*, etc.	
	(1) Lower seam—Nos. 31–5.	
	These shales pass down to shaly flags with the ribbed *Pseudomonotis*.	
D.	Escarpment Shales.	
	(4) A 3 in. Limestone.	
	(3) Thin paper shales with many Ammonites, reptilian bones, etc.	200
	(2) Middle Nodule bed.	
	(1) Earthy Limestone.	
C. 2.	Black Shales and yellow flags; with fish, mollusca, etc., and many *Posidonomya*: (Professor Garwood found a reptile rib in the Trident)	600
C. 1.	Lowest Nodule bed.	
B.	Unfossiliferous black shales: few exposures.	500
A.	Carboniferous Limestone.	

The succession above the Trias in this part of Spitsbergen was seen to the west of Lower Sassendal during an ascent, in company with Sir Martin Conway, of Mount Lusitania. The sequence is as follows, in descending order :—

Section II.

Jurassic.

(*g*) Grey to greenish flags with beds showing cauda-galli and cone-in-cone structures.
(*f*) Quartzose grit.
(*e*) Pebble bed and conglomerate. Snow covered.

Middle Trias.

(*d*) Black shales and upper nodule bed. Snow covered.
(*c*) Buff to greenish flags ; no fossils seen.
(*b*) Escarpment shales and flags.
(*a*) Middle Nodule bed.

Carboniferous.

Further east than the Mount Lusitania section an ascent from the de Geer Valley crossed the same general sequence.

Jurassic { (*h*) Grits capping the plateau.
(*g*) Flags with cauda-galli structure.
(*f*) Shales with intersecting and radial tracks (so-called Starfish bed).

(*e*) Hyperite sill which alters and bleaches the shales above and below.

Middle Trias { (*d*) Upper Nodule bed in black shales.
(*b–c*) Flags.
(*a*) Middle Nodule bed.

The intrusive character of the hyperite, and excellent sections of trough faulting are shown in coast sections between the de Geer Valley and Advent Bay.

From the eastern end of the Sassendal the Fulmar Valley affords a good section from the Carboniferous to the Jurassic ; and as the beds dip southward both the Carboniferous and Trias disappear, and the Jurassic beds form the chief rock exposures on both sides of the Upper Fulmar valley.

The character of the Jurassic and Cretaceous beds was best seen south of Advent Vale, in the scarps from Bunting Bluff to the Booming Glacier.

The succession may be thus summarized :—

		feet.
Middle Cretaceous	Brown shales. Quartzitic flags with few pebbles. Conglomerate with pebbles of quartz, chert, granite, etc.	500
Jurassic	Bunting Bluff Limestone. Ironstone nodules : fossiliferous.	400
	Rotten flags. Shales with plant remains ; few exposures.	1000

The intrusive nature of the hyperite is well shown in the north-east wall of the Fulmar Valley ; a sill oscillates slightly in level for some distance and then cuts steeply across the strata, becoming thinner in its ascent.

On Ammonites from Spitsbergen.

By L. F. Spath, M.Sc., F.G.S.

OF the rich collections of fossils made by Professors J. W. Gregory and E. J. Garwood, as members of Sir Martin Conway's expedition to Spitsbergen in 1896, only a few Labyrinthodont remains, so far, have been described [1]; but through the kind offices of Dr. A. Smith Woodward, the writer some time ago was entrusted with the naming of the Cephalopoda in those collections. The Ammonites are of the greatest interest, both from a palæontological and a stratigraphical point of view; and in view of the impossibility of publishing, in the near future, a full description of the fauna, with the necessary number of plates, it is intended to give a short preliminary account of these Cephalopoda. It is matter for regret that other groups of invertebrate fossils, such as the Triassic Pelecypoda, or the Upper Jurassic Aucellids, could not be dealt with, and their detailed study, probably, would yield important results. Spitsbergen Vertebrata, on the other hand, always have received considerable attention.[2]

The collections include 325 Ammonites from the Lower and Middle Trias, but there are no Upper Trias forms, such as the Carnian *Nathorstites* and *Dawsonites*, which are common enough on Bear Island, and which also have been recorded from Spitsbergen.[3] Triassic Nautiloidea are only represented by three examples of *Orthoceras*, one from the Lower Triassic "Nodule bed", another (without label) associated with an indistinct impression of an *Arctoceras* ?, and the third from a black limestone that may be of Middle Triassic age.[4]

Two fragmentary examples of *Atractites* sp. ? probably are the "*Belemnites*", mentioned in bed E_3 of Professor Gregory's section I, but there was no label with these specimens, though they were associated with Ammonites from Trident, Sassendal.

Thirty-one Ammonites are of Upper Jurassic (Kimmeridgian to Purbeckian) age, and a few fragments of Belemnites are referred to the same age. Finally, there are nine Cretaceous Ammonites, two of which can more or less definitely be dated as

[1] A. Smith Woodward, "On Two New Labyrinthodont Skulls of the genera *Capitosaurus* and *Aphaneramma*": *Proc. Zool. Soc.*, vol. ii, 1904.

[2] For bibliographies see e.g. C. Wiman, *Bull. Geol. Inst. Univ. Upsala*, vol. xvi, 1919, p. 85, and E. Andersson Stensiö, ib., p. 80.

[3] Wittenburg, P. v., "Üb. einige Trias. Fossil. v. Spitzbergen": *Trav. Mus. Géol. Pierre le Grand*, vol. iv, 1910, p. 38. The Upper Trias seems to be developed chiefly on the eastern side of Spitsbergen. It may be mentioned in this connexion that a collection of fossils, made this summer (1920) by Mr. W. J. Reynolds, and lately presented to the British Museum, includes a number of Middle Triassic Ammonites from Sassen Bay and Bell Sound, Spitsbergen; but both Upper and Lower Trias are unrepresented by Ammonites in this collection.

[4] A *Grypoceras* ? *nordenskjöldi*, Lindström sp., from "West of Fortress" near Cape Staratshin, West of Green Harbour, is in the Reynolds Collection.

Valanginian, whereas the others are doubtfully referred to the Albian. The stratigraphical information supplied unfortunately consists only of the data here copied from the labels attached to the specimens. The localities are mentioned in Sir Martin Conway's well-known book, *The First Crossing of Spitsbergen*,[1] and mostly recorded on the map appended to that work and to his paper in the *Geographical Journal*.[2] Since the mineral wealth of Spitsbergen is now attracting considerable attention,[3] it may be hoped that additional material and more extensive stratigraphical observations will soon be available.

After this paper was completed, Professor J. W. Gregory kindly sent the writer his "Note on the Sequence across Central Spitsbergen, from Advent Bay to Agardhs Bay", published herewith, so that it has been possible to insert some references to the beds mentioned in Professor Gregory's sections. But in view of the fact that some of the specimens were collected from loose blocks, that there are differences in the nomenclature that the writer is unable to settle, also that most of the specimens collected by Professor E. J. Garwood, especially the Jurassic ones, come from other localities, a complete list of the Ammonites, arranged according to the sections mentioned by Professor Gregory, cannot be given. The table at the end of the chapter on the Triassic portion of the Ammonite fauna, however, is an attempt at a correlation for that period.

I. Triassic.

The great majority of Ammonites belong to the Lower Trias, and can be referred to the following genera:—

Arctoceras[4]	*Prionites*
Olenekites ?	*Anasibirites*
Flemingites ?	*Keyserlingites*
Gyronites ?	Gen. nov. (*Danubites* ?,
Goniodiscus	*Xenodiscus* ?)
Tellerites	*Prosphingites* ?

The last two are represented by 100 and 66 specimens respectively; *Arctoceras* by 82. The latter genus includes, in addition to a number of less definitely identifiable species, seven forms described by

[1] 1897, J. M. Dent & Co., London.

[2] Vol. ix, No. 4, April, 1897, pp. 353–68, map, p. 472.

[3] See "Recent Developments in Spitsbergen", by Dr. R. N. Rudmose Brown: *Scott. Geogr. Mag.*, vol. xxxvi, April, 1920, No. 2, pp. 111–16; also the same author's "The Coal-fields of Spitsbergen": *Nature*, October 9, 1919. The summer population of Spitsbergen (1919) is estimated at 1,000.

[4] Hyatt, 1900 (in Zittel's *Text-book of Palæontology*, vol. i, p. 559), non *Arctoceras*, J. Böhm, 1899 ("Üb. Triad. Foss. v. d. Bären-Insel": *Zeit. Deutsch. Geol. Ges.*, vol. li, p. 326). In 1904 J. Böhm ("Üb. d. Obertriad. Fauna d. Bären-Insel": *Kon. Svensk. Vet.-Akad. Handl.*, vol. xxxvii, No. 3, 1903, p. 61) withdrew his *Arctoceras* in favour of Hyatt's term, and replaced it by another generic name for his Carnian group.

Mojsisovics,[1] namely *Arctoceras polare* (Mojs.), *A. simplex* (Mojs.), *A. whitei* (Mojs.), *A. blomstrandi* (Lindström), *A. lindströmi* (Mojs.)[2], *A. öbergi* (Mojs.), *A.? costatum* (Öberg). A number of small specimens, more evolute than the large examples, have lateral folds, or almost a spiniplicate ornament; but they occur with the young of undoubted *Arctoceras*, and, apparently, are connected with these by transitional forms. This may only be a case of convergence, for it is improbable that a spiniplicate development would give rise to forms that acquire costation on the outer whorl, as does *Arctoceras*. Only the smooth and more involute young, therefore, are considered to belong to *Arctoceras*. The others are like the young of "*Ceratites*" *decipiens* Mojsisovics, and of *Olenekites*, e.g. *O. sigmatoideus*, Mojsisovics sp. The latter also resemble the young of forms referred to below as gen. nov. (*Danubites*?, *Xenodiscus* ?) and Mojsisovics[3] derives *Danubites* from *Olenekites*. The small forms, here compared with *Olenekites*, however, have a smooth ventral area, whereas in the gen. nov. there are constrictions across the venter, apparently arising from a spiniplicate ornament. It is impossible to say at present whether *Arctoceras* should be attached to *Dinarites* (in Mojsisovics), to *Olenekites* and *Keyserlingites* (in Hyatt), to *Flemingites* (in Philippi), or to *Meekoceras* (in Stolley).

The writer may add that a true spiniplicate *Olenekites* in the British Museum is distinguished from the small forms here discussed by its square saddles, characteristic for Dinaritidæ.

Four specimens consist of umbilical impressions of very large shells, probably *A. lindströmi*, Mojsisovics sp.; their matrix indicates the *Posidonomya* shales. Fifteen examples are merely impressions in more or less weathered slabs of rock. But, whereas the well-preserved specimens and the umbilical casts above referred to clearly come from the *Posidonomya* shales[4] and generally are associated with numerous examples of *Posidonomya mimer* Öberg, these impressions are preserved in a very fine-grained black limestone, weathering yellow, and including (besides ? *Hærnesia*) large smooth *Pseudomonotis* of the type of *P.* (*Claraia*) *decidens* (Bittner)[5]

[1] "Arktische Triasfaunen": *Mém. Acad. Imp. Sci. St. Pétersbourg*, ser. VII, vol. xxxiii, No. 6, 1886, pp. 29–38.

[2] Non "*Arctoceras*" *lindströmi*. J. Böhm in J. G. Andersson ("Üb. d. Stratigr. und Tektonik d. Bären-Insel": *Bull. Geol. Inst. Univ. Upsala*, vol. iv, 1899, pt. ii, No. 8 (1900), p. 265), a *Nathorstites*, that has nothing to do with the Lower Triassic *Arctoceras lindströmi* (Mojsisovics).

[3] *Geb. u. Hallstatt*, Supplement, 1902, p. 329.

[4] Or rather from limestone-nodules in the bituminous, marly shales, mostly wrongly referred to in literature as "Posidonomya Kalk", as has been pointed out by Professor Wiman ("Ein paar Labyrinthodontenreste a. d. Trias Spitzbergens": *Bull. Geol. Inst. Univ. Upsala*, vol. ix, (1908–9), 1910, p. 34). Most of the specimens are from "Nodule Bed, Base of Trident, Sassendal"; three examples only came from "lowest line of nodules" or "Lowest Limestone" on Mt. Marmier.

[5] "Trias Brach. & Lamell.": *Mem. Geol. Surv. India*, *Pal. Indica*, ser. XV, *Himal. Foss.*, vol. iii, pt. ii, 1899, pl. i, fig. 24.

or of *P.* (*Claraia*) *aurita* (Hauer) in Diener.[1] These slabs are labelled "Lower Lamellibranch zone", Trident, but a few are from Sticky Keep, and there called "Upper Flags" (= Calcareous Flags, Bed above nodules ?). The presence of iron-pyrites in the latter, however, is reminiscent of the calcareous *Arctoceras* nodules in the *Posidonomya* shales, and the rock is hard, whereas the somewhat similarly weathering examples from the "Upper Lamellibranch zone", with a very large *Pseudomonotis* (*Eumicrotis*), generally have a more earthy, brownish appearance. One *Arctoceras* impression, merely labelled "Sassendal", may have come from this higher zone, but it is for future workers to investigate the range of *Arctoceras* in the shales and flags above the "Nodule bed".

A specimen of *Arctoceras blomstrandi* (Lindström) was attached to the umbilical impression of a very large shell, characterized by strong spiral ornament, on account of which the specimen is doubtfully referred to *Flemingites*. The longitudinal striation in this genus, however, is considerably finer than it is in the Spitsbergen example; and the writer at one time was inclined to compare this specimen with certain *Phloioceras* and other *Nautiloidea*. It seems most probable, however, that the example is a *Flemingites*, though spiral striation is also indicated in certain *Arctoceras*.[2] Another specimen of *Arctoceras* and numerous *Posidonomya mimer* are to be observed in the same specimen.

Two of the specimens referred to *Goniodiscus* are closely comparable with *Meekoceras gracilitatis* White,[3] but the periphery is slightly broader. Young examples of the same form, however, have the costation of *Anasibirites*, and are so nearly related to the forms here referred to that genus, to *Prionites* and *to Tellerites*, that the resemblance to the genus *Meekoceras* (with perfectly smooth inner whorls) can only be a case of convergence. The suture-line of this new species of *Goniodiscus* agrees with that of *G. typus* Waagen,[4] but the external saddle is a little wider in the Spitsbergen form. The latter also has a narrower and more sharply defined periphery.

Another new species of *Goniodiscus* has coarse pleats at the middle of the side, near the end of the shell, and thus is transitional to

[1] "Triassic Faunæ of Kashmir": *Mem. Geol. Surv. India, Pal. Indica*, N.S., vol. v, Mem. No. 1, 1913, pl. v, fig. 9.

[2] E.g. *A. öbergi* (Mojsisovics), loc. cit., p. 33, pl. viii, fig. 3. *Ceratites concentricus* Öberg ("Om Trias-Först. fr. Spitsbergen": *K. Svenska Vet. Akad. Handl.*, vol. xiv, No. 14, 1877, p. 15, pl. ii, fig. 12) has concentric markings, but Mojsisovics (loc. cit., p. 8), who examined the type, states that they are the result of crushing. To judge by a number of specimens in the Reynolds Collection, this form is a crushed *Ptychites* of the *Daonella* Beds.

[3] In Hyatt & Smith, "The Triassic Ceph. Gen. of America": Prof. Paper No. 40, U.S. Geol. Surv., 1905, p. 143, pl. xii, figs. 7–9. Dr. C. T. Trechmann lately presented to the British Museum (Nat. Hist.) a very fine series of Triassic Ammonites from California, Nevada, and Idaho, U.S.A., including many topo-types of Hyatt & Smith's species.

[4] "Salt Range Fossils: II. Fossils from the Ceratite Formation": *Mem. Geol. Surv. India, Pal. Indica*, ser. XIII, 1895, p. 128, pl. ix, figs. 7–10.

Prionites. A third form, at last, has these *Prionites*-folds very close, resembling in shape *Anasibirites hircinus* Waagen sp.,[1] but with the costæ pronounced only at the middle of the side, not near the periphery. The cross-sections of the last two forms approach to that of *Prionites tuberculatus* Waagen.[2]

A new species of *Prionites* is like the above in the character of the inner whorls. These somewhat resemble *Meekoceras sibiricum* Mojsisovics,[3] but are more evolute, i.e. more like *M.* sp. ind. aff. *jolinkense* Krafft in Diener.[4] On the other hand, the outer whorl agrees with that of the example of *Prionites tuberculatus* (Waagen), figured by Frech.[5] The periphery, however, still suggests the *Goniodiscus-Anasibirites* stock; and since Waagen's type of *Prionites* is a much earlier form, it is quite possible that the forms of the *Stephanites*-zone do not belong to this genus. A large but fragmentary specimen of a *Prionites* sp. nov. aff. *tuberculatus* Waagen, has a more rounded outer whorl that strikingly suggests a transition to *Keyserlingites*.

A small specimen, probably belonging to a new form of *Tellerites*, but slightly malformed and not showing the suture-line, has the sigmoidal ornament of *T. furcatus* (Öberg), but the deeply channelled periphery of *Hedenstræmia* already at the diameter of Mojsisovics' small specimen,[6] which latter, then, is still rounded. This ammonite, also, cannot be separated from the other "*Meekoceras*"-like forms here discussed, and certainly has nothing to do with the Middle Triassic *Norites*, with which *Tellerites* has been associated by Mojsisovics and Haug.

The genus *Anasibirites* is represented by thirteen examples from the Nodule Bed of the Trident, Sassendal, including one curious new form, transitional to *Goniodiscus*, and others comparable with such species as *A. ibex* (Waagen), *A. angulosus* (Waagen), and *A. spiniger* (Krafft). Several more small examples are attached to large specimens of *Keyserlingites*, of which the collection includes nine fine examples, belonging to a new species, near to *K. middendorfi* (Keyserling).[7] The Spitsbergen form, however, has a simpler suture-line, with only bifid external lobe.

The numerous specimens here referred to *Prosphingites*? include

[1] Ib., p. 123, pl. ix, fig. 4.

[2] Ib., p. 58, pl. v, fig. 2.

[3] Loc. cit., 1886, p. 85, pl. xi, figs. 1–6.

[4] Loc. cit., 1913, p. 25, pl. iv, fig. 3.

[5] *Lethæa Geogn.*: II. Mesozoic; vol. i, Trias, pt. ii, 1905, pl. xxviii, fig. 2.

[6] Loc. cit., 1886, pl. x, fig. 19*a–b*, p. 80. Öberg's original figure (loc. cit., pl. iii, fig. 6) is much nearer the new form.

[7] In Mojsisovics, loc. cit., pl. iii, p. 38. The form figured and described by Diener ("The Cephalopoda of the Muschelkalk": *Mem. Geol. Surv. India, Pal. Indica*, ser. xv, Himalayan Fossils, vol. ii, Trias, pt. ii, 1895, p. 28, pl. v, fig. 7) as *Ceratites* sp. ind. ex aff. *C. middendorfi* (Keyserling) from the Muschelkalk, like his Middle Triassic *Sibirites prahlada* (ib., p. 37, pl. vii, fig. 5), have nothing to do with the Lower Triassic forms here discussed. There is not one Muschelkalk form found in association with the latter at Spitsbergen.

several new forms, externally resembling such species as *Xannites herberti* Diener and *X. hindostanus* Diener,[1] but with toothed lobes. *Prosphingites austeni* Hyatt & Smith [2] has a similar suture-line, but is too involute; on the other hand, some of the specimens greatly resemble the inner whorls of *Prosphingites czekanowskii* Mojsisovics,[3] though in this form, as also in *Paranannites aspenensis* Hyatt & Smith,[4] the external lobe is too complicated.[5] The radial folds and pseudo-constrictions of some examples are pronounced: other forms are quite smooth and globose, but they agree in suture-lines. Only one example was attached to a typical *Arctoceras*, but many small specimens came out of the matrix of a large specimen of *A. lindströmi* (Mojsisovics) from "lowest line of nodules in flags, 400–450 feet above camp, Mt. Marmier".

The numerous forms referred to above as gen. nov. (*Danubites*?, *Xenodiscus*?) belong to a group of which "*Dinarites*" *evolutus* Waagen,[6] and *Ceratites minutus* Diener [7] [non *Dinarites minutus* Waagen] probably are examples. The former has been compared with *Bittnerites*, and also with *Xenodiscus*, and some forms referred to the latter genus by Diener, e.g. *X.* cf. *lissarensis* Diener [8] and *X. comptoni* Diener,[9] indeed, greatly resemble the later forms. But the Spitsbergen Ammonites, probably, are nearly related to *Danubites*, e.g. *D. hyperboreus* (Mojsisovics), and to *Olenekites*, though the constrictions and coarse folds of the inner whorls somewhat resemble the Middle Triassic *Cuccoceras*. Again, the notched periphery of some of the more involute forms has the appearance of that of *Anasibirites ceratitoides* (Waagen),[10] but the suture-line of the whole group is very close to that of the form described as *Xenaspis marcoui* by Hyatt & Smith.[11] There is no resemblance to the Indian forms of *Xenodiscus*, with flattened periphery, in the British Museum Collections, nor to the forms of *Xenodiscus*, recorded with *Paratirolites* and *Stephanites* from Djulfa by Stoyanow,[12] and supposed to correspond with those of the Himalayan *Hedenstrœmia*-beds.

On the whole, then, the group is, perhaps, closer to the Arctic

[1] "The Cephalopoda of the Lower Trias": loc. cit., Himalayan Fossils, vol. ii, pt. i, 1897, pp. 68, 69, pl. vii, figs. 2, 3.

[2] Loc. cit., 1905, p. 72, pl. vii, figs. 1–4.

[3] Loc. cit., 1886, p. 64, pl. xv, figs. 10–12.

[4] Loc. cit., 1905, p. 81, pl. viii, figs. 1–15; pl. lxxiii, figs. 1–30.

[5] *Prosphingites ali* Arthaber (*Albania*, 1911, pl. xxii, fig. 6) has a similar external lobe, but the saddles and lobes are only about half as high in the Spitsbergen species. *Paranannites mediterraneus* Arthaber (ib., pl. xviii, fig. 8), on the other hand, has quite a different suture-line.

[6] Loc. cit., 1895, p. 32, pl. x, fig. 3.

[7] "Triad. Ceph. Fauna d. Ostsibir. Küstenprovinz": *Mém. Com. Géol. St. Pétersb.*, vol. xiv, No. 3. 1895, p. 15, pl. ii, fig. 6.

[8] Loc. cit. (Kashmir, 1913), p. 5, pl. i, fig. 11.

[9] Ib., p. 10, pl. ii, fig. 7.

[10] Loc. cit., 1895, p. 115, pl. viii, fig. 10.

[11] Loc. cit., 1903, p. 116, pl. vii, figs. 26–33.

[12] "On the Character of the Boundary of Palæozoic and Mesozoic near Djulfa": *Verh. Russ.-Kais. Min. Ges.*, ser. II, vol. xlvii, 1909, pp. 86, 87.

Danubites than to any other development, and it should be mentioned that Waagen's *D.? evolutus* also is associated with *Anasibirites*. The young of some of the Spitsbergen forms also resemble the example figured by Diener [1] as *Danubites* nov. sp. ind., with evolute whorls, parabolæ-like costæ, and constrictions like Diener's Fig. 7*a*. Only the suture-line in this form of *Danubites* has the external lobe subdivided, whereas in the Spitsbergen group it is entire, like that of *Ceratites minutus* Diener non Waagen. The largest specimen of the group, a form very near to *D.? evolutus* Waagen, attains a diameter of 70 mm.

Apart from over ninety specimens of this group of *Danubites*? the collections include some more or less unidentifiable impressions of similar Ammonites in a black limestone, possibly from the "Lower Lamellibranch zone"; also some in a softer, more brownish rock that may belong to the "flags above the nodule bed", with the large ribbed *Pseudomonotis*. It should be mentioned, however, that according to Stolley,[2] a very hard, splintery limestone occurs in large nodules above the *Posidonomya* shales. Stolley would include this in the Lower Muschelkalk, and considers *Arctoceras lindströmi* and *A. costatum* to belong to this bed. But the large specimen of *A. lindströmi*, referred to above, from the "lowest line of nodules in flags, 400–450 feet above camp, Mt. Marmier", has *Posidonomya* attached to the matrix, and the writer cannot separate it from the fauna of the *Posidonomya* nodules. The impressions referred to represent evolute more or less smooth shells, and their attribution to *Danubites*, of course, is quite uncertain. One specimen in a soft, dark shale resembles *Meekoceras* (*Gyronites*) *nathorsti* J. Böhm,[3] but the periphery is not shown.[4]

Two specimens require special mention. They were discovered, accidentally, in what almost is a bone-bed, among portions of Labyrinthodonts and Cœlacanthid fish-remains, associated with *Posidonomya*, to judge by other specimens, and undoubtedly of the age of the *Posidonomya* shales. One of these specimens is a crushed and incomplete example of ? *Gyronites*, comparable with *G. aplanatum* (White),[5] which also has been recorded from the *Arctoceras* bed by Stolley [6]; the other is a fragment, resembling "*Danubites*" *strongi* Hyatt & Smith [7] in its angular periphery, in ornament, and in evolution, but having the lateral folds a little closer.

[1] Loc. cit., (1895, Ostsibir.), pl. i, fig. 7.

[2] "Zur Kenntn. d. Arkt. Trias": *N. Jb.*, vol. i, 1911, p. 122.

[3] "Ub. Trias Verstein. v. Bell-Sunde auf Spitzbergen": *Arkiv f. Zool.*, vol. viii, 1913, No. 2, p. 11, pl. i, figs. 17–19.

[4] From Professor Gregory's section I it will be seen that there are 600 feet of black shales and yellow flags (from which these *Danubites* may have come) between the undoubtedly Lower Triassic "Nodule Bed" (C_1) and the probably Middle Triassic "Earthy Limestone" (D_1).

[5] See Hyatt & Smith, loc. cit., 1905, p. 146, pl. xi.

[6] Loc. cit., 1911, p. 123, pl. ix, fig. 5.

[7] Loc. cit., 1905, p. 165, pl. ix, figs. 4–10.

One slab from the "Nodule bed" of the Trident, Sassendal, full of *Posidonomya mimer*, and containing, in addition to *Arctoceras*, a fragment of one of the species of the gen. nov. (*Danubites* ?), also includes a portion of what Dr. A. Smith Woodward considers to be *Belonorhynchus wimani* A. Smith Woodward.[1] The writer, at first, thought that these plentiful *Danubites* ? might be what Wiman [2] calls the commonest Ceratite of the "fish-bed". Other fish-remains in the British Museum (*Acrolepis*), and some Cœlacanthid remains associated with *Arctoceras* and *Posidonomya mimer*, also are preserved in the black limestone that must have come from nodules in the *Posidonomya* shales. But only a few isolated specimens of *Danubites* ? are found associated with *Arctoceras* and *Posidonomya*, whereas the nodules in which these *Danubites* ? occur in clusters are crowded with a very convex *Pseudomonotis*. This also characterises the matrix of *Anasibirites* and *Keyserlingites*, but it does not seem to be found in the slabs with *Posidonomya mimer*, where a less convex and smoother form (still of the *P. boreas* type) rarely occurs.

Professor Wiman [3] recorded his Labyrinthodont remains from the lower part of the *Posidonomya* shales of Mt. Marmier, and thought that the "fish-bed", not quite at the base of the Trias, might not represent the exact horizon from which Mojsisovics' *Arctoceras* fauna was obtained.[4] From the evidence of the specimens labelled "Lower Nodule Bed", and from Professor Gregory's section I, it would appear as though both the typical *Arctoceras* fauna, recorded by Mojsisovics, corresponding with the "*Posidonomya* nodules" aforementioned, and the *Anasibirites–Keyserlingites–Prionites–Goniodiscus* assemblage, recorded here from the "*Pseudomonotis* nodules", occurred at about the base of the "*Posidonomya* shales". The fish-bed of Professor Wiman [5] also may be near this horizon, C_1.

Whether the whole of the 600 feet of "*Posidonomya* shales" above this horizon belong to the Lower Trias is doubtful. The "Lower Saurian horizon" of Professor Wiman, 300 feet above the fish-bed, may coincide with the bed from which ? *Gyronites aplanatus* and ? *Danubites strongi* have been recorded, those species being known to occur in the "*Meekoceras*" beds of Idaho and California. Hyatt & Smith [6] record *Anasibirites* from the same beds, so that

[1] "Notes on some Fish-remains from the Lower Trias of Spitsbergen": *Bull. Geol. Inst. Univ. Upsala*, vol. xi, 1912.

[2] "Ichthyosaurier a. d. Trias Spitzbergens": *Bull. Geol. Inst. Univ. Upsala*, vol. x, 1910–11, Nos. 19 and 20, p. 127.

[3] Loc. cit., 1910, p. 34.

[4] Loc. cit., 1911, p. 127.

[5] Ib., p. 126.

[6] Loc. cit., 1905, p. 49. In 1914 (*The Middle Triassic Marine Invertebr. Faunas of North America*, p. 4: Correlation Table) Professor Perrin-Smith put the Spitsbergen *Posidonomya* "Limestones" as equivalent to the *Meekoceras* Beds of the Himalayas and the *Proptychites* Beds of the Ussuri, that is to say,

the two species mentioned (the identification of which is not definite) may belong to the uppermost Lower Trias. In the nodule bed a doubtful *Flemingites* has been found, and the *Anasibirites* and *Keyserlingites* are characterized by simple sutures, so that horizon C_1 may very probably be somewhere near the border-line between the *Flemingites* beds below and the *Stephanites* zone above.[1] The latter probably includes the lower half or more of the *Posidonomya* shales, but an exact correlation is impossible in the present state of our knowledge.

(*To be continued.*)

Precambrian Para-Gneisses of Southern Eyre Peninsula, South Australia.

By C. E. Tilley, Emmanuel College, Cambridge.

(*Concluded from p. 259.*)

4. Origin of the Garnet Gneisses.

THE composition of the garnet gneisses already described allows them to be treated collectively in a discussion of their origin. It will be clear from the foregoing account that the mineralogical composition and the textures developed are those characteristic of the highest grades of metamorphism. They are, therefore, to be included amongst the Kata-zone gneisses of Grubenmann. The pronounced banding in these rocks must be interpreted as a result of initial differences in composition of the original sediments. This banding therefore represents the bedding and has been preserved through the various stages of metamorphism, eloquent testimony that the amplitude of diffusion in metamorphism is in general of quite limited dimensions.

far too low in the Lower Trias. On the other hand, the Sibirian Olenek Beds, probably, like the *Stephanites*-zone of the Salt Range and the Himalayan *Hedenstræmia* Beds, can be correlated with the Spitsbergen *Posidonomya* Shales or at least their lower part (see also Diener, "Das Alter der Olenekschichten Sibiriens": *Centralbl. f. Min*, etc., 1908, p. 233).

[1] The Lower Triassic fauna of Këira in Albania, that Diener (Kashmir, 1913, p. 121) considers to be homotaxial with the *Hedenstræmia* stage of India, and that, at least in part, corresponds with the *Columbites* fauna of Idaho, shows a striking resemblance to the apparently contemporaneous fauna here described, but contains many higher (and later ?) types. Arthaber's treatment of this fauna, as his whole classification, is not very fortunate (see L. F. Spath, "Notes on Ammonites": Geological Magazine, Vol. LVII, 1919, p. 224); but the affinities of e.g. some of the forms that Arthaber includes in his heterogeneous *Dagnoceras* (*Arctoceratinæ*!) with certain Spitsbergen Ammonites here referred to *Anasibirites*, *Goniodiscus*, *Prionites*, etc., are most interesting. They show that, as mentioned above, the "*Meekoceras*" and "*Xenodiscus*" of the *Stephanites* zone probably are only heterochronous homœomorphs of the lower, true *Meekoceras* and *Xenodiscus*. In the case of the latter, the forms of the *Ophiceras* layer may have to be separated generically both from the Permian type and from the Upper Eotriassic forms, that is to say, there are at least three independent developments that successively take on the "*Xenodiscus*" characters.

That the rocks have developed under a not inconsiderable shearing stress is evidenced by the development of biotite, quartz and graphite in flakes elongated in a plane of foliation, which is here coincident with the banding surface, thus serving to accentuate the banding. We have already referred to the development of garnet in lenticular grains with noteworthy elongation parallel to the foliation, and to the occurrence of uniformly oriented sillimanite.

This streaky development of sillimanite in orthoclase is strongly suggestive of development under actual shearing movement.

Granulation of the enclosing mineral might be expected in such cases, but it is quite clear that if this movement has taken place the evidence of granulation of the enclosing felspar has been destroyed by healing. The most probable explanation appears to be that crystallization of sillimanite occurred under conditions permitting shearing movement, and at temperatures sufficiently high to inhibit granulation of felspar.

To the case of garnet the same remarks may apply. The lens-like character of the garnet porphyroblasts, with their longer axes parallel to the foliation, is a feature of a number of the Sleaford gneisses. Here, again, the enclosing mineral shows perfect optical continuity at the periphery of the garnet grains. However this may be, it is quite clear that in many of the garnet grains the elongate character cannot be due to any rolling out of original garnet crystals, and in so far as this is true, it shows that the rocks have been developed under sufficient shearing stress to elongate a mineral so high in the crystalloblastic series. Even in the case of certain abnormally elongate garnet lenticles, it must be conceded that any postulated rolling out was involved in the same epoch of metamorphism, and before the temperature had fallen sufficiently to allow of granulation. Shearing stress has therefore played a not unimportant rôle in the development of these gneisses. The element of stress has also left its mark after crystallization had been completed, the clues to which are the development of rows of fluid pores in quartz grains at right angles to the direction of foliation, and in the case of the Hutchison garnet gneisses, the extensive cataclasis. This cataclasis is associated only with the gneisses of the northern area, and is absent in the Sleaford rocks.

It was pointed out in a previous paper that the dolomites associated with these gneisses showed no evidence that shearing stress had played any important rôle. The propriety of these two apparently conflicting statements calls for some remark. In the case of pure dolomites we are concerned with a mineral whose habit is not favourable to the development of elongate crystals, and there is a further factor involving the facility with which the carbonate minerals recrystallize. With regard to mineralogical evidence of shearing stress, the abundant presence of the anti-stress mineral forsterite indicates that the hydrostatic element was dominant.

As has been pointed out by Harker,[1] shearing stress has a

[1] Harker, Pres. Address Geol. Soc., 1918, p. lxxix.

maximum value which is a function of temperature, and this maximum stress diminishes with rising temperature, so that at very high temperatures the stress element in metamorphism may be quite subordinate. During the metamorphism of the sediments under consideration, and at the temperature prevailing, shearing stress was adequate to orient biotite, quartz, and flakes of graphite, and in some cases elongate individual garnet crystals during their crystallization in the rigid garnet gneisses, but only a granular texture was imparted to the dolomite rocks.

Doubtless in general an important factor in this different behaviour is the position of dolomite with regard to quartz and biotite in the crystalloblastic series.

That at a given temperature the upper limit of shearing stress is lower for the carbonate rock than for the more rigid quartzo-felspathic type, seems undoubted, and the essential factor in this behaviour is the ease with which the carbonate minerals recrystallize, and the consequent tendency to a viscous flow limiting the range of shearing stress. The presence of carbon dioxide as a solvent in rocks of this class contributes to this end.

As to the nature of the original sediments from which these garnet gneisses are derived, all traces of original clastic structure have been destroyed by the complete recrystallization involved. Nor in the nature of the case are the evidences of progressive metamorphism by which the succession of mineralogical changes might be determined clearly defined. The mineralogical composition of the group is that which might be expected in the metamorphism of sediments of the composition of shales, grading into more quartzose types, and even merging into arkoses, where the felspathic constituent is dominant.

The two prime constituents of all the rocks are quartz and felspar, and the important additional minerals are biotite, garnet, sillimanite, and spinel.

Analysis.	*Sleaford gneiss.*	*Vermont slate.*	*Norm.*	*Osann class.*
SiO_2	64·35	62·37	Quartz	S = 70·4
Al_2O_3	16·21	15·43	21·7	A = 5·5
Fe_2O_3	1·01	1·34	Orthoclase	C = 1·6
FeO	6·91	5·34	31·1	F = 12·0
MgO	2·95	3·14	Albite	M = —
CaO	1·35	0·77	14·1	T = 3·4
Na_2O	1·70	1·14	Anorthite	K = 1·5
K_2O	5·25	4·20	6·7	
H_2O+	0·32	3·71	Corundum	a = 5·8
H_2O-	0·14	0·34	5·4	c = 1·7
other constituents	n.d.	2·02	Hypersthene 19·3	f = 12·5
			Magnetite	
	100·19	99·80	1·4	

An analysis of a less quartzose variety of the type β gneisses has been made.

The constituents are perthitic orthoclase quartz, plagioclase garnet, biotite, magnetite, and a few flakes of graphite can also be detected.

The analysis of this rock is given on p. 307, and with it the analysis of a slate from Vermont.

An inspection of this analysis shows that the available criteria for a sedimentary origin are satisfied.

Magnesia and potash are in excess of lime and soda respectively. The presence of corundum in the norm to the extent of 5·4 per cent is also a partial confirmation.

The analysis is close to that of a slate from Vermont, described by T. N. Dale,[1] and the correspondence would be still closer if the slate analysis were recalculated after removal of excess water.

A comparison with the analyses listed by Grubenmann indicates its grouping with Class II—the aluminium silicate gneisses. If the procedure of Grubenmann be adopted in representing graphically the composition of the gneisses by an adaptation of the Osann projection, we have the following triangular diagram (Fig. 3).

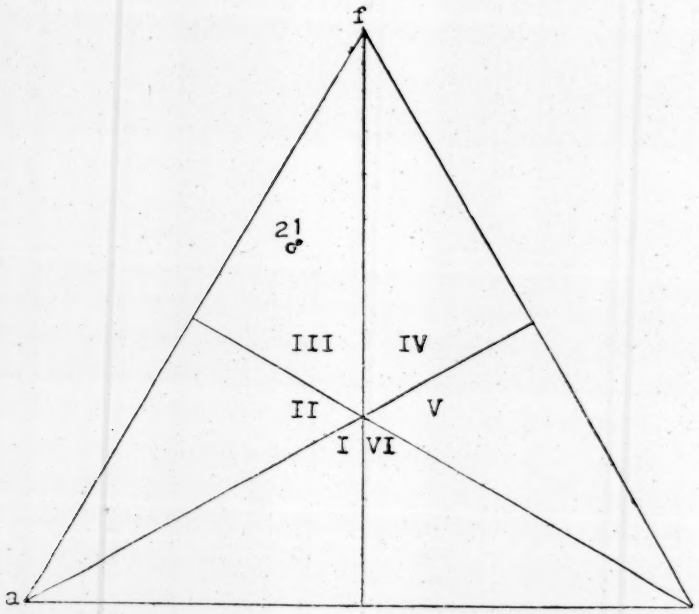


FIG. 3.—(Osann.) 1. Garnet gneiss, Sleaford Bay. 2. Mean position of the aluminium silicate gneisses.

[1] Clarke, *Bull. U.S.G.S.*, No. 419, p. 211.

The parameters correspond closely with those for the "group mean" of the analyses cited by Grubenmann.

The abundant minerals garnet and sillimanite serve as indices of the origin of the dominant potash felspar. The high-grade metamorphism of argillaceous material results usually in the formation of potassic felspar from the more aluminous constituents as the micas, either sericite or biotite. It is obvious that the formation of new felspar from these constituents involves the setting free of an excess of alumina to be disposed of. In these rocks this has appeared either as garnet or sillimanite or more rarely spinel.

Dealing first with garnet. This is essentially an almandine type in which the FeO constituent is dominant, as the analysis shows. Its formation can be represented by an equation of the type

$$(1)\quad \left.\begin{matrix}2H_2KAl_3(SiO_4)_3\\ Mg_2Fe_4(SiO_4)_3\end{matrix}\right\} + 3\,SiO_2 \rightleftharpoons 2KAlSi_3O_8 + 2Fe_2MgAl_2(SiO_4)_3 + 2H_2O$$

biotite + quartz = orthoclase + garnet

The excess alumina is here combined with the iron magnesia constituents in garnet.

The validity of an equation of this nature is evident by the relationships of certain garnets as seen in thin slices, where its association with biotite and quartz is one of genetic significance.

The reversibility of this equation is postulated at least for those cases where the degradation of garnet to biotite is to be observed, the potash being obviously derived from neighbouring orthoclase.

In some of the rocks garnet occurs in association with green spinel, and this relationship is genetic (cf. Fig. 2 (*b*)). The equation for this reaction is of the type [1]

$$(2)\quad \left.\begin{matrix}2H_2KAl_3(SiO_4)_3 +\\ MgFe_3(SiO_4)_2\end{matrix}\right\} SiO_2 = 2KAlSi_3O_8 + Fe_2MgAl_2(SiO_4)_3 + FeAl_2O_4 + 2H_2O$$

Those types in which quartz and felspar are the chief constituents and garnet and sillimanite very subordinate, can obviously only have derived that amount of felspar from biotite or sericite in accordance with the amount of alumina set free to be absorbed in garnet and sillimanite. The felspar in excess of this amount must be derived by the recrystallization of original felspar, and where this was large the original sediment was an arkose.

[1] In these equations the *quantitative* proportions of orthoclase to garnet, sillimanite, and spinel will obviously depend on the ratio H : K in the mica involved. In this, and following equations, the mica must be regarded as *mechanical* mixtures of sericite, and biotite of the composition shown in equation (1). For simplicity the gross composition of these mixtures is shown. Whether Clarke's view, or the hypothesis of Tschermak for the constitution of the micas is adopted, it is quite clear that the main types muscovite and biotite form mix crystals only to a very limited degree. In a recent paper in a study of a large number of analyses of the mica group, H. E. Boeke ("Die Grenzen der Mischkristallbildung in Muscovit und Biotit": *Neues Jahrbuch*, 1916, pp. 83–117) shows that the compositions of muscovite and biotite are to be represented in two distinct and separate fields, each of which is quite limited in extent.

The occurrence of sillimanite in these rocks shows that it has arisen (*a*) from sericite

$$(3)\ H_2KAl_3Si_3O_{12} + SiO_2 = KAlSi_3O_8 + Al_2SiO_5 + H_2O$$

This equation explains the genetic association of needles of sillimanite in orthoclase where ferromagnesian constituents are not present.

(*b*) from biotite.

In these cases the sillimanite is intimately associated with garnet, and in certain cases the ferromagnesian constituents have been absorbed in spinel to the exclusion of garnet.

The equation representing this association is of the type

$$(4)\ \left.\begin{matrix}3H_2KAl_3(SiO_4)_3\\ MgFe(SiO_4)\end{matrix}\right\} = 3KAlSi_3O_8 + MgFe(Al_2O_4)_2 + Al_2SiO_5 + 3H_2O$$

It is not improbable that some of the magnetite associated with sillimanite in similar cases has been derived by a degradation of the biotite molecule.

The above equation is of a type expected only in the highest grades of metamorphism, and it is of interest to compare it with the products obtained by direct fusion of biotite. Bäckström, on fusion of biotite, found among the products olivine, leucite, spinel, and glass, and Doelter records the same products with the exception of leucite. The actual products obtained would appear to depend on the composition of the mica, and in highly aluminous micas olivine would probably not appear. According to Vernadsky [1] muscovite yields corundum and sillimanite on fusion. These products are very similar to those shown in the equation above, and afford an interesting parallel to the processes at work in high-grade metamorphism.

The occurrence of spinel calls for some remark. Whenever this mineral is present it is surrounded by a shell of garnet or sillimanite, and it has not been observed in direct contact with quartz, although this may be abundantly present in the rock. This is as might be expected, as its union with silica would give rise to cordierite according to the equation

$$(5)\ (Mg, Fe)(Al_2O_4)_2 + 5SiO_2 = (Mg, Fe)(O)_2.2Al_2O_3.5SiO_2$$

This reaction is doubtless a reversible one, and if so the dissociation temperature must exceed those temperatures normally obtaining in high-grade metamorphism.[2]

A spinel of composition near hercynite, under the same condition, would yield almandine and sillimanite, assuming the pure iron cordierite has no stable existence.

$$(6)\ 3FeAl_2O_4 + 5SiO_2 = Fe_3Al_2(SiO_4)_3 + 2Al_2SiO_5$$

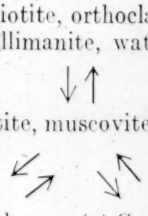
Although cordierite has been carefully looked for in these rocks, no trace of it has been observed.

[1] Cf. Clarke, *Bull. U.S.G.S.*, No. 616, p. 396.

[2] Artificial cordierite dissociates on melting at atmospheric pressures (Rankin and Merwin, *Amer. Journ. Sci.*, vol. xlv, 1918, pp. 301–25).

In the garnet-cordierite-sillimanite gneisses the iron-magnesia constituents of the rock are allotted between garnet, cordierite, and biotite.

The equilibria between these minerals can be represented by the scheme



and the minerals of the systems (*a*), (*c*), and (*d*) are found together. In the rocks under discussion, however, there has been some prevailing condition by which the equilibria have been driven completely from (*a*) to (*c*) and (*d*).

Whether this is connected with the very high ferrous iron content of the rock compared with magnesia, and the possible instability of an iron-rich cordierite, must await further investigation.

Correlation of the garnet gneisses with similar gneisses in other areas.

Rocks of this type can be matched in pre-Cambrian tracts in other parts of the world. The most striking analogues are the garnet gneisses of the Grenville series of North America.

Adams [1] describes garnet gneisses of the sediment type associated with crystalline limestones in the region north of the island of Montreal, Quebec, and more recently in the Haliburton-Bancroft area of Ontario.[2]

These rocks are extensively developed in the Grenville series in the Adirondack region of New York, and have been described by Kemp,[3] Smyth, Cushing, and others.

The field relations and petrographical constitution of the rocks described by these investigators are remarkably similar to those of the rocks described in the foregoing.

Metamorphosed sediments of this type containing a green spinel have been studied from various localities. Spinel is developed in the well-known contact rocks surrounding the tonalite of the Mount Aviolo region in the Eastern Alps as described by Salomon.[4] The references to the earlier literature will be found in a paper by J. J. H. Teall.[5] More recently Sauerbrei [6] has studied sedimentary gneisses

[1] Adams, *Amer. Journ. Sci.*, vol. l, 1895, pp. 58–69.
[2] Adams and Barlow, *Mem. No. 6, Geol. Surv., Canada*, 1910, pp. 173–91.
[3] Kemp, *Amer. Assoc. Adv. Sci.*, 1900, pp. 157–84.
[4] Salomon, *Zeit. d. deutsch. geol. Gesell.*, vol. xlii, 1890, s. 450.
[5] Teall, *Proc. Geol. Assoc.*, vol. xvi, 1899, pp. 61–74.
[6] Sauerbrei, *Neues Jahrbuch*, vol. xxxiv, 1912, pp. 1–41.

containing this mineral, and in the Phillipsburg Quadrangle, Montana, Calkins and Emmons[1] have described garnet-cordierite gneisses of which the same mineral is a constituent. The modes of occurrence, and associations of all these rocks, indicate that spinel is a product of the highest grades of metamorphism, and appears in rocks subject to intense thermal alteration or as members of Grubenmann's Kata-zone.

Summary.

1. Garnet gneisses of sedimentary origin are described from the oldest group of sediments recognized in Southern Eyre Peninsula, South Australia. The high-grade metamorphism which these rocks have undergone has resulted in the development of felspar, garnet (almandine), sillimanite, and green spinel.

2. The mineralogical association of these constituents is described, and their genetic relations are discussed.

3. A sedimentary origin of these gneisses is attested by their interbanding with undoubted sediments, their mineralogical composition, and lastly by chemical analysis.

4. In the garnet gneisses developed in the Grenville series of North America, notably those of the Adirondack region, and in the province of Quebec, these para-gneisses find their most striking analogues.

EXPLANATION OF PLATE III.[2]

Fig. 1.—Garnet-sillimanite Gneiss, Mine Creek, Hundred of Hutchison. × 32 diameters. The constituents are garnet, biotite, sillimanite, orthoclase, and quartz. The features illustrated in the photomicrograph are the development of elongate garnet porphyroblasts, the poikiloblastic texture, and the transverse fissures in the garnet occupied by biotite, the degradation product. Sillimanite is also seen in bunched aggregates included in orthoclase.

Fig. 2.—Garnet Gneiss, Mine Creek, Hundred of Hutchison. × 32 diameters. The constituents are garnet, biotite, sillimanite, orthoclase, plagioclase, quartz, green spinel, and magnetite. The features noted in the photomicrograph are the development of a system of cracks in the garnet grains, parallel to the foliation of the rock, and the association of green spinel and sillimanite (spinel included within sillimanite in one case) as inclusions in the largest garnet crystal shown.

[1] Emmons and Calkins, Prof. Paper No. 78, *U.S.G.S.*, 1913, p. 39.

[2] Issued with June number.

Notes on the Fauna of the Lower Devonian Beds of Torquay.

By F. R. Cowper Reed, Sc.D., F.G.S.

Part II. Brachiopoda.

Orthis (*Schizophoria*) *provulvaria* Maurer.

1864. *Orthis hipparionyx* ? Davidson (pars.), *Mon. Brit. Dev. Brach.*, vol. iii, p. 90, pl. xvii, fig. 10 (excl. cet.).
1882. *Orthis hipparionix* or *striatula* Etheridge, Geological Magazine, p. 156, Pl. IV, Fig. 8.
1882. *Spirifera cultrijugata* ? Etheridge, ibid., p. 155, pl. iv, fig. 9.
1893. *Orthis provulvaria* Maurer, *Neues Jahrb. f. Miner. Geol.*, i, p. 7, t. iii, figs. 1–4.
1904. *Orthis* (*Schizophoria*) *provulvaria* Drevermann, *Palæontographica*, Bd. l, p. 267, t. xxx, figs. 29, 30; t. xxxi, figs. 11–19.
1920. *Orthis* (*Schizophoria*) *provulvaria* Reed, *Journ. Torquay Nat. Hist. Soc.*, vol. ii, No. 6, pp. 340, 341.

Drevermann has already described and figured this species, and there can be no doubt that the shell from Smugglers' Cove described by Etheridge as "*O. hipparionix* (*sic*) or *striatula*" belongs to it. There are several much better examples in the Sedgwick Museum from Smugglers' Cove, which fully confirm this conclusion. The specimen from Looe, figured by Davidson (op. cit. *supra*) as *O. hipparionyx* ? is believed by Drevermann to belong to *O. provulvaria*, but he does not mention Etheridge's shell from Smugglers' Cove. There is also one imperfect example in the Sedgwick Museum from the New Cut. Williams and Breger[1] consider Schnur's[2] *Orthis hipparionyx* (*non* Vanuxem) from Prüm in the Eifel, to be identical with Hall's[3] *Schuchertella woolworthana* from the Lower Helderberg of New York.

Horizon.—Lower Devonian (Staddon Grits).

Localities.—Smugglers' Cove, Torquay (S. 58); New Cut, Torquay (S. 30).

Orthis (*Dalmanella*) *circularis* Sowerby ?

Sowerby's type[4] of this species was from the Rhenish Lower Devonian, but the name seems to have been subsequently applied to various members of a group of species which are difficult to distinguish when the material is poorly preserved, as is the case with the Torquay specimens. The synonymies which Kegel[5] and Williams & Breger[6] have given for this species may be questioned, and Fuchs[7] has recently split up the group into a number of distinct species which were previously regarded as identical with *O. circularis* or merely varieties of it.

Horizon.—Meadfoot Beds.

Locality.—Meadfoot, Torquay.

[1] Williams & Breger, Prof. Paper 89, *U.S. Geol. Surv.*, 1916, pp. 34, 39.
[2] Schnur, *Palaeontographica*, vol. iii, 1853, p. 217, pl. xl, figs. 1*a–c*.
[3] Hall, *Tenth Ann. Rep. New York State Cab. Nat. Hist.*, 1857, p. 48, figs.
[4] Sowerby, *Trans. Geol. Soc.*, ser. II, vol. vi, 1842, p. 409, pl. xxxviii, fig. 12.
[5] Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxvi, 1913, p. 101, t. v, fig. 7.
[6] Williams & Breger, op. cit., 1916, pp. 59, 60.
[7] Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxix, 1915, pp. 8–16.

Stropheodonta Murchisoni (D'Archiac & de Verneuil).

1840. *Orthis Murchisoni* D'Archiac & de Verneuil, *Trans. Geol. Soc.*, ser. II, vol. vi, p. 371, pl. xxxvi, fig. 2.

1882 ? *Strophomena Murchisoni* Barrois, *Mem. Soc. Geol. Nord.*, ii, 1, p. 241, pl. ix, fig. 6.

1887. *Strophomena Murchisoni*, Béclard, *Bull. Soc. belge. geol. Pal. Hydr.*, 1, p. 89, pl. iv, figs. 17–19.

1902. *Stropheodonta Murchisoni* Drevermann, *Palæontographica*, vol. xlix, p. 110, t. xiv, figs. 4–6, 7 (?), 8.

This species was recorded by Kayser[1] in 1889 from the Meadfoot Beds below Kilmorie, and by Upfield Green[2] from Cornwall. There are several examples from Kilmorie, and possibly one from Smugglers' Cove, in the Sedgwick Museum, but none are perfect and most are distorted. The characteristic coarse ribbing is, however, well seen, and in one case the fine radial striation between the ribs, which is specially mentioned by D'Archiac and de Verneuil[3] in a variety from Asturias (separated by Oehlert[4] as a distinct species, *Str. diffusa*), is well preserved. Drevermann (op. cit. *supra*) says the ribs are sometimes simple and sometimes divided, and that at the submarginal geniculation of the shell they either disappear or are resolved into bundles of fine riblets. In one of our specimens the ribs become obsolete before reaching the margin, but they seem nearly always to be simple. There is one example of this species in the Jermyn Street Museum ($\frac{29}{40}$), labelled simply "Torquay", but probably it came from Meadfoot.

The group of species to which *Str. Murchisoni* belongs is compact and well differentiated, and it includes *Str. Sedgwicki*, D'Arch. and de Vern., *Str. acutiplicata* (Oehl. & Dav.),[5] *Str. diffusa* Oehl. (if separated from *Str. Murchisoni*), *Str. virgata* Drev.,[6] *Str. fascigera* Drev.,[7] and the American forms *Str. galatea* (Billings),[8] and *Str. parva* Hall.[9]

Horizons.—(1) Meadfoot Beds; (2) Red Beds (Staddon Grits).

Localities.—(1) Kilmorie (S. 32, 54); (2) Smugglers' Cove (S. 59); (3) "Torquay" (? Meadfoot) $\frac{29}{40}$ M.P.G.

Stropheodonta Sedgwicki (D'Arch. & de Vern.) var. *rudis* Kegel.

This species,[10] which has been described in some detail by Drevermann,[11] and compared with several other species of Lower

[1] Kayser, *Neues Jahrb. f. Min. Geol.*, vol. i, 1889, p. 188.

[2] Upfield Green, Geol. Mag., Dec. V, Vol. I, 1904, p. 406.

[3] D'Archiac & de Verneuil, *Bull. Soc. Géol. France*, ser. II, vol. ii, 1845, p. 477, pl. xv, fig. 7.

[4] Oehlert, *Bull. Soc. Géol. France*, ser. III, vol. xxiv, 1896, p. 868.

[5] Oehlert & Davoust, *Bull. Soc. Géol. France*, 3, vol. vii, 1879, p. 708, pl. xiv, fig. 3.

[6] Drevermann, *Palæontographica*, Bd. xlix, 1902, p. 111, t. xiv, figs. 10, 11.

[7] Ibid., p. 112, t. xiv, fig. 12.

[8] Clarke, *Mem. 9, U.S. State Mus.*, 1908, p. 188, pl. xxxv, figs. 15–26.

[9] Hall, *Palæont., New York*, vol. iv, 1859, p. 85, pl. xi, figs. 5, 11.

[10] D'Archiac & de Verneuil, *Trans. Geol. Soc.*, ser. II, vol. vi, 1840, p. 371, pl. xxxvi, fig. 1; Oehlert, *Bull. Soc. Géol. France*, ser. III, vol. xvii, 1899, p. 776, pl. xix, fig. 8; pl. xxi, fig. 1.

[11] Drevermann, *Palæontographica*, Bd. l, 1904, No. 6, p. 271, t. xxxi, figs. 21–6.

Devonian age, is closely allied to *Str. Murchisoni* and *Str. virgata* Drev.,[1] but it varies somewhat in the development and number of its ribs, and consequently Kegel[2] has established the variety *rudis* for those forms possessing few and coarser ribs which occur in the Taunus quartzite. Two fragmentary valves from the Smugglers' Cove red beds have been recognized, one of which shows the cardinal region of the internal cast of a brachial valve, and both agree with Kegel's variety in the character of the ribbing rather than with the type.

Horizon.—Red Beds (Staddon Grits).

Locality.—(1) Smugglers' Cove (S. 100); small cove immediately south of Smugglers' Cove (Shannon Coll.).

Stropheodonta gigas (McCoy).

It is unfortunate that McCoy's[3] type of this species, which is from Looe, is in a poor state of preservation, and only shows the external ornamentation. Davidson[4] figured the interior of a pedicle-valve and Drevermann[5] the interior of a brachial valve, giving at the same time a full description of the specific characters. At Meadfoot it occurs in a tough siliceous bluish cleaved slate, with numbers of *Chonetes plebeia*, *Ch. sarcinulata*, *Spirifer* sp., and *Pleurodictyum problematicum*. One specimen ($\frac{29}{40}$) in the Jermyn Street Museum, simply labelled "Torquay", occurs in the rotten calcareous, sandy rock of Kilmorie, and shows the internal cast of a pedicle valve, while another (1245) in the Ussher Collection shows the denticulations along the hinge-line of the brachial valve. It is possible that *Strophomena protæniolata* Béclard,[6] is identical with this species.

Horizon.—Meadfoot Beds.

Localities.—Meadfoot (S. 49, 50); East of South Bank (Ussher Coll., 1245 M.P.G.); "Torquay" (? Kilmorie) $\frac{29}{40}$ M.P.G.

Leptæna rhomboidalis (Wilckens).

1769. *Conchita rhomboidalis* Wilckens, *Nachr. Selt. Verstein.* p. 77, pl. viii, figs. 43, 44.

This well-known Silurian species, which does not seem to be specifically separable from that occurring in the Lower Devonian of Europe and America, is represented in the Sedgwick Museum by one good example from a dark grey lustrous slate, labelled "The Knoll, South of Meadfort Sands". Williams and Breger (op. cit. p. 32, pl. viii, figs. 8–12) describe specimens of it from the Chapman Sandstone of Maine, and give references to the American literature,

[1] Ibid., Bd. xlix, 1902, No. 2, p. 111, t. xiv, figs. 10–11.

[2] Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxvi, p. 103, t. vi, figs. 1, 2.

[3] McCoy, *Syn. Brit. Palæoz. Foss. Woodw. Mus.*, 1872, p. 386, pl. ii, fig. 7.

[4] Davidson, *Mon. Brit. Dev. Brach.*, vol. iii, 1864, p. 83, pl. xvi, figs. 1–3 (non 4).

[5] Drevermann, *Palæontographica*, Bd. l, 1904, p. 273, t. xxxii, figs. 1–4.

[6] Béclard, *Bull. Soc. belge Geol. Pal. Hydr.*, i, 1887, p. 93, t. v, fig. 2.

and others have described it from many Devonian localities in Europe.

Horizon.—Meadfoot Beds.

Locality.—The Knoll, South of Meadfoot Sands (S. 52).

Chonetes plebeia Schnur.

1853. *Chonetes plebeia* Schnur, *Palæontographica*, Bd. iii, Lief. 4, p. 226, t. xlii, figs. 6*a–d* (excl. cet. ?).
1878. *Chonetes sarcinulata* var. *plebeia* Kayser, *Abhandl. geol. specialk. Preuss.*, Bd. ii, Heft iv, p. 200, t. xxx, figs. 13, 14.
? 1883 *Chonetes plebeia* Oehlert, *Bull. Soc. Géol. France*, ser. 3, vol. xi, p. 517, pl. xiv, figs. 3, 3*a–c*.
1889. *Chonetes plebeia* Barrois, *Faune Calc. d'Erbray*, *Mem. Soc. Geol. Nord.*, iii, pl. iv, fig. 4.
1889. *Chonetes plebeia* Kayser, *Abh. k. preuss geol. Landesanst*, N.F., Heft i, p. 63, t. vii, figs. 2–5; t. x, fig. 7.
1897. *Chonetes plebeia* Whidborne, *Quart. Journ. Geol. Soc.*, vol. liii, p. 454, pl. xxxiii, figs. 1, 2.
1915. *Chonetes semiradiata* Sowerby, Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxix, p. 19, t. iv, fig. 11.

This small species occurs in considerable abundance in the Red Beds of the New Cut and in the slaty beds of Meadfoot, but is often distorted, and always crushed. Whidborne has also recorded *Ch. plebeia* from the Morte Slates, but Davidson made no mention of the occurrence of this species in the British Isles. It is a conspicuous form in the Lower Coblenzian of the Continent, but ranges up into the Upper Coblenzian, and perhaps higher.

Horizons.—(1) Red Beds (Staddon Grits); (2) Meadfoot Beds.

Localities.—(1) New Cut and Lincombe Drive (S. 14, 15, 16, 28) (T. $\frac{2}{3}$); (2) Meadfoot (S. 48, 49, 50, 64) (M.P.G. $\frac{2}{3}$) (M.P.G. 1208, 1210, 1211 Ussher Coll.); (4) New Drive from Hope's Farm (M.P.G. 1157, Ussher Coll.); (5) South of Hope Farm, edge of Bramblebrake (M.P.G. 1181, Ussher Coll.).

Chonetes sarcinulata Schlotheim.

The characters of this species and its separation from other allied forms have always been in doubt owing to the difficulty of deciding what fossil Schlotheim intended to designate by this name.[1] Davidson[2] put it (together with *Ch. sordida* (Phill.[3]) as a probable synonym of *Ch. hardrensis* Phill., which is typically a Carboniferous species. But if we adopt Kayser's[4] views on the matter, we appear to have it represented in the Torquay district at Meadfoot and below Kilmorie, though, unfortunately, none of the specimens which I have examined are well preserved. Kayser[5] himself recorded it from the Meadfoot Beds below Kilmorie, and there is a specimen from this locality ($\frac{2}{3}$) thus labelled by De Koninck in 1873 in the

[1] Williams & Breger, Prof. Paper 89, *U.S. Geol Surv.*, 1916, p. 47.
[2] Davidson, *Mon. Brit. Dev. Brach.*, vol. iii, 1864, p. 94.
[3] Phillips, *Palæoz. Foss. Dev. Cornw.*, p. 62, pl. xxv, fig. 104.
[4] Kayser, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft i, 1889, p. 62, t. vii, figs. 4, 6–8; t. x, fig. 8.
[5] Kayser, *Neues Jahrb. f. Min. Geol.*, vol. i, 1899, p. 188.

Jermyn Street Museum. Whidborne[1] has doubtfully referred some specimens from the Morte Slates of Treborough to this species. Fuchs[2] has separated off some of the shells figured by Kayser under this name as a new species, *Ch. oblonga*, and also considers *Ch. subquadrata* Roem. to be merely a variety of *Ch. sarcinulata*, but it is difficult to make out the alleged specific differences in the Torquay specimens. It is much to be regretted that there exists such difference of opinion and uncertainty with regard to its specific distinction, for Gurich[3] states that it is the most widely distributed species of the Lower Devonian. The American species, known as *Ch. novascoticus* Hall,[4] may perhaps be identical.

Horizon.—Meadfoot Beds.

Localities.—Meadfoot (S. 48, 49, 50); below Kilmorie ($\frac{2}{2}\frac{3}{8}$ M.P.G.).

Camarotæchia daleidensis (Roemer).

1844. *Terebratula daleidensis* F. Roemer, *Rhein. Uebergangsgeb.*, p. 65, t. i, fig. 7.
1853. *Terebratula daleidensis* Schnur, *Palæontograph.* vol. iii, p. 172, t. xxii, fig. 1.
1887. *Rhynchonella daleidensis* Béclard, *Bull. Soc. belge geol. Pal. Hydr.* i, p. 85, pl. iv, figs. 9–11.
1899. *Rhynchonella daleidensis* Kayser, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft i, p. 43, t. v, figs. 2, 3.
1909. *Rhynchonella daleidensis* Gürich, *Die Leitfossilien*, Lief. 2, Devon, p. 146, t. xlv, fig. 6.

There is a considerable range of variation in this species, and its separation from *Rh. livonica* von Buch, has not always been recognized, but it lacks the parietal ribs on the sinus and on the saddle, which are present in that species. Kayser[5] remarks that it much resembles *Rh. nympha* Barr., but has no lateral excavations on the shoulders of the valves. Drevermann[6] points out that *Rh. daleidensis* is referable to Hall & Clarke's subgenus *Camarotæchia*. *Rh. hexatoma* Schnur, which Fuchs[7] describes from the Remscheider Beds, seems hardly separable as a distinct species. The specimens in the Sedgwick Museum were obtained from the Red Beds of the New Cut, but Kayser[8] recorded it from the cliffs and beach below Kilmorie.

Horizons.—(1) Red Beds (Staddon Grits); (2), (3), (4) Meadfoot Beds.

[1] Whidborne, *Quart. Journ. Geol. Soc.*, vol. liii, 1897, p. 455, pl. xxxiii, figs. 3–5.

[2] Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lviii, 1909, p. 57, t. viii, figs. 17, 18; t. ix, figs. 1–5.

[3] Gürich, *Die Leitfossilien*, ser. II, Devon, 1909, p. 130, t. xlii, fig. 10.

[4] Williams & Breger, op. cit., p. 45, pl. ix, figs. 11, 12, 15, 16, 19; pl. x, figs. 1–3, 5–16, 18–29, 32, 33.

[5] Kayser, *Abh. geol. spec. Karte Preuss.*, Bd. ii, Heft iv, 1878, p. 142.

[6] Drevermann, *Palæontographica*, Bd. l, 1904, p. 262.

[7] Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lviii, 1909, p. 69, t. x, fig. 5.

[8] Kayser, *Neues Jahrb. f. Min. Geol.*, i, 1889, p. 188.

Localities.—(1) New Cut (S. 17, 31); (2) below Kilmorie; (3) South of Hope Farm, new drive to Hope's Nose (M.P.G. 1169, 1175, 1179, 1180 Ussher Coll.).

Rensselæria (*Rhenorensselæria*) *crassicosta* Koch.

Kegel [1] has put this species together with *R. strigiceps* F. Roem. into a new subgenus, *Rhenorensselæria*, which he has established on account of the difference in the structure of the hinge apparatus of the brachial valve from the typical American representatives of the genus, which has for its type *R. ovoides* Eaton. The subgeneric separation of this European group of species is reasonable, and the name may be conveniently adopted. Amongst the fossils in the Sedgwick Museum from the Red Beds of the New Cut, Torquay, there is one pedicle-valve which may with some confidence be ascribed to Koch's species *R. crassicosta*, which Fuchs [2] and Kegel [3] have described and figured in some detail. Our specimen measures about 16 mm. in length, and shows the characteristic shape and ribbing.

Horizon.—Red Beds (Staddon Grits).

Locality.—New Cut, Torquay (S. 32).

Rensselæria (*Rhenorensselæria*) cf. *strigiceps* F. Roemer.

In the Sedgwick Museum, Cambridge, there is the internal cast of the posterior portion of a brachial valve of a large brachipood, which shows the peculiar and interesting characters of the typical American representatives of *Rensselæria*, with which Clarke [4] includes Hall's genus *Amphigenia*,[5] the difference between them lying only in the fusion or separation of the dental plates, and the presence or absence of a low supporting septum. Our specimen[6] shows a large massive triangular hinge-plate fused to the inner surface of the brachial valve, but obscurely divided into two halves by a shallow median groove; each half has its face slightly hollowed and from its inner anterior angle arises the slender crural process on each side. Between the bases of the crura, which are close together, the hinge-plate projects as a very short blunt, low, median process or ridge, on each side of which is situated a rather deep pit excavated in the thickness of the shell. The hinge-plate is also traversed by a small median, subcylindrical tunnel (the visceral canal), which arises at the beak, and runs from this point forwards through the substance of the hinge-plate to open into the interior of the shell by means of a funnel-shaped aperture on its thick anterior face. This tunnel seems to become larger and quadrangular in cross-section in its posterior

[1] Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxvi, 1913, pp. 126–32.
[2] Fuchs, *Jahrb. k. preuss. geol. Landesanst.*, 1903, p. 44. t. vi, fig. 1.
[3] Kegel, op. cit., p. 135, t. vi, figs. 14, 15, and references.
[4] Clarke, *Mem. New York State. Mus.*, No. 9, pt. i, 1908, p. 165; ibid., pt. ii, 1909, p. 81.
[5] Hall & Clarke, *Palæont. New York.*, vol. viii, Brach. ii, p. 252.
[6] Reed, *Journ. Torquay Nat. Hist. Soc.*, vol. ii, No. 6, 1920, p. 341.

half. The dental sockets are long, deep, and tubular, and lie parallel to the hinge-line. From each of the pits in front of the hinge-plate proceeds a narrow, sinuous, linguiform vascular marking, which closely embraces the posterior end and sides of the muscle-scar. The latter itself is distinct, well-marked, elongate-oblong in shape, with straight subparallel edges, and is divided by a narrow linear median ridge proceeding from the hinge-plate between the posterior adductor scars, which are crossed by irregular transverse wrinkles. The anterior adductor scars are not preserved, the anterior part of the shell being broken off and missing. The precise shape of the shell cannot be determined accurately, owing to the distortion of the specimen, but it seems to have been subcircular rather than oval or oblong, and to have been of large size, measuring probably about 70 mm. in width. No impression of the exterior is available to show the nature of the external ornamentation. As Clarke has pointed out, the radial lineation in *Rensselæria* frequently dies out on the posterior part of the shell, so that the surface becomes smooth.

There is a second specimen in the Sedgwick Museum of a somewhat smaller shell of the same type, consisting also of the internal cast of the umbonal region of the brachial valve, but it is less perfect than the one above described. The internal characters of *R. strigiceps* (Roem.) have been recently described by Kegel [1] from an internal cast, and they seem to agree with our specimens, except that the latter have a visceral canal in the hinge-plate as in the American forms. Probably these Torquay specimens belong to a new species, but we cannot base one on these internal casts.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie, Torquay (S. 82) (S. 83).

Rensselæria (*Trigeria*) *Gaudryi* (Oehlert).

According to Kegel,[2] who has recently discussed the classification of the various species which have been referred to the genus *Rensselæria*, the species *R. confluentina* Fuchs [3] is identical with Oehlert's *Trigeria Gaudryi*,[4] and the genus *Trigeria* can only be regarded as a subgenus of *Rensselæria*. It may be suspected that Davidson's *R.? striatissima*,[5] from the Middle ? Devonian of Hope's Nose, and possibly also his so-called variety of [6] *R. strigiceps* Roem. from the Middle ? Devonian of Hagginton Hill, Ilfracombe,

[1] Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxvi, 1913, pp. 126, 127, text-fig. 3; p. 136, t. vi, figs. 16, 17.

[2] Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxvi, 1913, pp. 121–31.

[3] Fuchs, *Jahrb. k. preuss. geol. Landesanst.*, Bd. xxiv, 1907, p. 50, t. vii, figs. 7–14; t. viii, figs. 1–14; id., *Abh. k. preuss. geol. Landesanst.* N.F., Heft lviii, 1909, p. 73.

[4] Oehlert, *Bull. Soc. Geol. France*, ser. III, vol. v, 1877, p. 593, pl. x, fig. 8; id., *Bull. Soc. Études Sci. Angers*, 1885, p. 2, figs. 10–17. Walther, *Neues Jahrb. f. Min. Geol.*, Beil. Bd. xvii, 1903, p. 57, fig. 1.

[5] Davidson, *Mon. Brit. Dev. Brach.*, Suppl. v, 1882, p. 19, pl. i, figs. 20, 20*a*.

[6] Davidson, id., vol. iii, 1864, p. 10, pl. iv, figs. 5–7.

belong to the same species. In the Sedgwick Museum there is a fairly complete, though crushed and distorted internal cast of a specimen from the New Cut, Torquay, which may without doubt be referred to Fuchs' *R. confluentina*; it possesses about fifty fine low, rounded, simple ribs on the surface, crossed by delicate concentric striæ, and shows the curved dental plates and median septum in the interior, and in its shape and other characters agrees with the specific definition.

Horizon.—Red Beds (Staddon Grits).

Locality.—New Cut, Torquay (S. 19).

Rensselæria (*Trigeria*) *Guerangeri* (De Verneuil).

1850. *Terebratula Guerangeri* De Verneuil, *Bull. Soc. géol. France*, ser. I, vol. vii, p. 780.
1869. *Rhynchonella Guerangeri* De Verneuil in Tchihatcheff's "Asie Mineure", *Appendice à la Faune dévon. du Bosphore*, p. 35, pl. xxi, fig. 4.
1878. *Trigeria Guerangeri* Bayle, *Explic. Carte géol. France*, Atlas, pl. xii, figs. 9–12.
1883. *Terebratula* (*Centronella*) *Guerangeri*, Oehlert, *Bull. Soc. Études Sci. d'Angers*, p. 1, pl. i, figs. 1–11; pl. ii, figs. 1–6.
1889. *Centronella Guerangeri* Kayser, *Zeitschr. deut. geol. Gesell.*, Bd. xli, p. 294, t. xiv, figs. 3–7.
1894. *Trigeria Guerangeri* Hall & Clarke, *Palæont. New York*, vol. viii, Brach. ii, p. 272, text-fig. 189.
1900. *Centronella Guerangeri* Kayser in Toulas' "Geol. Reise nach Kleinasien", *Beitr. Paläont. Geol. Oesterr. Ungarns u. d. Orients*, xii, Heft i, 1899, p. 37.
1920. *Trigeria Guerangeri* Reed, *Journ. Torquay Nat. Hist. Soc.*, vol. ii, No. 6, pp. 340, 341.

In the Torquay Museum there are certain small, indifferently preserved casts and impressions of a shell from the Staddon Grits, south-west of Brixham, averaging 10 mm. in length, which are apparently referable to this species, and especially resemble Kayser's figures. The Lower Devonian shell described by Fuchs [1] as *Centronella taunica* is closely allied to *R. guerangeri*, according to Kegel,[2] and may, therefore, also be compared with our specimens.

Horizon.—Red Beds (Staddon Grits).

Localities.—East of the Dart, south-west of Brixham (T. $\frac{2}{6}^{0}$, $\frac{1}{6}^{0}$, $\frac{1}{2}^{8}$); Downton, near Dartmouth (T. $\frac{1}{2}^{7}$).

Newberria cf. *Deshayesi* (Caillaud).

1861. *Terebratula Deshayesi* Caillaud, *Bull. Soc. Geol. France*, ser. III, vol. xviii, 1861, p. 333, figs. A, B.
1878. *Meganteris*, sp. Kayser, *Alt. Fauna d. Harzes*, p. 141, t. xxviii, figs. 1–3.
1889. *Megalanteris Deshayesi* Barrois, *Faune Calc. d'Erbray, Mem. Soc. Geol. Nord.*, iii, p. 151, pl. x, fig. 6*a*, *b*.

The internal cast of the greater part of a brachial valve from Kilmorie, which is in the Sedgwick Museum, shows characters which

[1] Fuchs, *Jahrb. k. preuss. geol. Landesanst.*, xxxiii, ser II, Heft 1, 1912, p. 62, t. v, figs. 5–8.
[2] Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxvi, 1913, pp. 132, 139.

indicate its reference to Hall's genus, *Newberria*,[1] of which the type is *Rensselaria ? johannis* Hall.[2] Our shell may be compared with *N. deshayesi* (Caillaud) from the European Lower Devonian, and it shows well the elongate subovate adductor scars divided by a thin ridge (as in Caillaud's figure), and the very narrow submarginal dental sockets which Hall & Clarke illustrate (op. cit. pl. lxxviii, fig. 11) in *N. johannis*. Gürich [3] adopts the name *Newberria* for the two European species, *Terebratula caiqua* D'Arch & Vern. and *T. amygdala* Goldf., but he does not mention *T. deshayesi* Caill. or *Meganteris inornata* D'Orb., both of which Hall & Clarke (op. cit. pp. 264, 281) consider are referable to *Newberria*. *Dielasma rhenana* Drevermann [4] may also belong to this genus.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 67*a*).

Tropidoleptus rhenanus Frech.

1853. *Leptæna laticosta* Schnur, *Palæontographica*, Bd. iii, p. 220, t. xl, fig. 2.
1864. *Leptæna* or *Orthis laticosta* ? (Conrad), Davidson, *Mon. Brit. Dev. Foss.*, vol. iii, p. 87, pl. xvii, figs. 1–3.
1882 ? *Rhynchonella laticosta* Etheridge, Geol. Mag., Dec. II, Vol. IX, p. 156, Pl. IV, Fig. 7.
1897–1902. *Tropidoleptus rhenanus* Frech, *Lethæa Geogn.*, Bd. ii, Lief. i, p. 143, footnote 1.
1902. *Tropidoleptus carinatus* var. *rhenana* Drevermann, *Palæontographica*, Bd. xlix, p. 99, t. xii, figs. 11, 12.
1913. *Tropidoleptus carinatus* Kegel, *Abh. k. preuss. geol Landesanst.*, N.F., Heft lxxvi, p. 104.

Davidson's figures of the British examples do not show the decrease in the strength and distinctness of the lateral ribs, which is a characteristic feature, and is well seen in specimens in the Jermyn Street Museum. The number of the ribs varies, and according to Drevermann (op. cit.) is of little importance, and there is a considerable range of variation in the closely allied or scarcely separable American species (*Tr. carinatus* Conr.), from the Hamilton Formation.[5] It is probable that Etheridge's *Rhynch. laticosta* Dav., from Smugglers' Cove, should be referred to *Tr. rhenanus*, for it seems to possess the typical characters. Upfield Green [6] has recorded it from the "Gedinnian" of Cornwall, and Davidson had previously given Looe as a locality for its occurrence. It seems to be fairly common in the Meadfoot Beds, but crushed specimens of *Ch. plebeia* have often been mistaken for it, and are difficult to distinguish.

Horizon.—(1) Meadfoot Beds; (2) "Lower Devonian".

[1] Hall, *10th Ann. Rep. New York State Geol.*, 1891, pp. 91–9, pls. v, vi.
[2] Hall & Clarke, *Palæont. New York*, vol. viii, Brach. ii, pp. 261, 281, pl. lxxviii, figs. 10–16.
[3] Gürich, *Die Leitfossilien*, Lief. ii, Devon, 1909, p. 148.
[4] Drevermann, *Palæontographica*, Bd. xlix, 1902, p. 98, t. xii, figs. 7–10.
[5] H. S. Williams, Prof. Paper 79, *U.S. Geol. Surv.*, 1913, pp. 36–42, pls. i, ii.
[6] Upfield Green, Geol. Mag., Dec. V, Vol. I, 1904, p. 406.

Localities.—(1) Meadfoot (S. 35, 29); "Torquay" M.P.G. $\frac{29}{21}$, $\frac{29}{21}$, $\frac{29}{40}$ pass); (2) Smugglers' Cove (? Etheridge's *Rh. laticosta*); Beach, south of Smugglers' Cove (M.P.G. 1188 Ussher Coll.); south of Hope Farm, edge of Bramblebrake (M.P.G. 1176, 1182, 1181 Ussher Coll.); field south of Oxlea Hill (M.P.G. 1218, 1219 Ussher Coll.); Windmill Hill, south of Paignton (M.P.G. 1223 Ussher Coll.).

Spirifer subcuspidatus Schnur.

The commonest species of *Spirifer*, occurring in the Kilmorie beds, may be referred to *Sp. subcuspidatus* Schnur,[1] or to one of its varieties, as interpreted by Fuchs.[2] None of the Torquay specimens are well preserved, but the internal casts and external impressions, both of which are usually fragmentary or distorted, are sufficient to identify them with this species rather than with the allied *Sp. hystericus* Schloth,[3] *Sp. carinatus* Schnur,[4] *Sp. incertus* Fuchs,[5] and *Sp. crassifulcitus* Spriesterb.[6] The points of distinction between these species is by no means a matter of agreement amongst Continental palæontologists, but *Sp. cuspidatus* apparently differs from *Sp. hystericus* chiefly by its more numerous ribs. R. and E. Richter[7] have recently revised the members of the group of *Spirifer subcuspidatus* and introduced several new specific names, but our poor material does not admit of such precise differentiation.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 34, 45, 54, 55).

Spirifer mediorhenanus Fuchs?

1909. *Spirifer mediorhenanus* Fuchs, *Abhandl. k. preuss. geol. Landesanst.*, N.F., Heft lviii, p. 67, figs. 1–6.
1915. *Spirifer mediorhenanus* Fuchs, ibid., Heft lxxix, p. 25, t. vi, figs. 6–20.
1920. *Spirifer arduennensis* ?, Reed, *Journ. Torquay Nat. Hist. Soc.*, vol. ii, No. 6, p. 339.

The one impression of a brachial valve from Kilmorie, which was previously referred by me (op. cit. supra) with a query to Schnur's species *Sp. arduennensis*, seems now to be better placed in Fuchs' species *Sp. mediorhenanus*, judging from his figures and description. Our specimen has the transverse shape and pointed angles of his shell, and the six or seven broad, slightly subangular closely placed ribs on each lateral lobe; the low, rounded median saddle is somewhat flattened, and expands rather rapidly in width to the front

[1] Scupin, *Palaeont. Abhandl.*, viii, 1900, p. 19, t. i, figs. 13, 14.

[2] Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lviii, 1909, pp. 60–3, t. ix, figs. 11–15.

[3] Drevermann, *Palaeontographica*, Bd. l, 1904, p. 253, t. xxx, figs. 15–19; Scupin, op. cit., p. 12, t. i, figs. 3–5.

[4] Scupin, op. cit., p. 26.

[5] Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxix, 1915, p. 24, t. vi, figs. 2–5.

[6] Spriesterbach, ibid., N.F., Heft lxxx, 1915, p. 7, t. ii, 5–8; t. iii, figs. 1–9.

[7] R. and E. Richter, *Jahrb. Nassau. Vereins f. Naturk.*, Jahrg. 72, 1920, pp. 26–38.

margin, where it equals about three lateral ribs. The concentric growth-ridges are conspicuous on the whole surface of the valve.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 60).

Spirifer parcefurcatus Spriesterbach?

1915. *Spirifer parcefurcatus* Spriesterbach, *Abh. k. preuss. geol. Landesanst*, N.F., Heft lxxx, p. 16, t. iv, figs. 7–14; t. v, figs. 1–3.

1920. *Spirifer Bischofi*? Reed, *Journ. Torquay Nat. Hist. Soc.*, vol. ii, No. 6, pp. 340, 342.

This species is closely allied to *Sp. bischofi* A. Roem.,[1] to which an example from Smugglers' Cove is an imperfect condition has been previously referred by me. But according to Spriesterbach (op. cit.) it differs in the ribbing of the fold and sinus. Scupin [2] included this form in *Sp. bischofi*, and Drevermann [3] has also discussed the variable characters of the latter species and its relation to other species. It is almost certain that the shell from Lynton, figured by Whidborne[4] as *Sp. daleidensis* Stein., which is a closely allied form, should be referred to *Sp. parcefurcatus* or to *Sp. bischofi*.

Horizon.—Red Beds (Staddon Grits).

Locality.—Smugglers' Cove (S. 57).

Spirifer decheni Kayser?

In the Whidborne collection of fossils from Meadfoot in the Sedgwick Museum there is a crushed and distorted specimen, 35–40 mm. in length and rather more in width, which shows the external impression and internal cast of a large species of *Spirifer*, and is apparently referable to *Sp. decheni* Kayser,[5] which Scupin [6] and Assmann [7] consider identical with *Sp. fallax* Giebel,[8] and closely allied to *Sp. primævus*. Our shell specially resembles Oehlert's [9] and Barrois'[10] figure of *Sp. decheni*, and is subrhomboidal in shape with 10–12 coarse angular ribs on each side of a broad angular sinus in the pedicle valve.

Horizon.—Meadfoot Beds.

Locality.—Meadfoot (S. 80).

[1] A. Roemer (Giebel), *Silur. Fauna Unterharz.*, 1858, p. 29, t. iv, fig. 3.

[2] Scupin, *Palæont. Abhandl.*, Bd. iii, 1900, p. 73, t. vii, figs. 1–3.

[3] Drevermann, *Palæontographica*, Bd. l, 1904, p. 252, t. xxix, figs. 15–17.

[4] Whidborne, Geol. Mag., Dec. IV, Vol. VIII, 1901, p. 531, Pl. XVII, Fig. 6.

[5] Kayser, *Abh. geol. specialK. Preuss.*, Bd. ii, Heft iv, 1878, p. 165, t. xxii, figs. 1, 2.

[6] Scupin, op. cit., p. 85.

[7] Assmann, *Jahrb. k. preuss. geol. Landesanst.*, 1910, Bd. xxxi, Heft i, p. 138, t. vi, figs. 5–11.

[8] A. Roemer (Giebel), *Silur. Fauna Unterharz.*, 1858, p. 32, t. iv, fig. 1.

[9] Oehlert, *Bull. Soc. Geol. France*, ser. 3, vol. xvii, 1889, p. 779, pl. xxi, fig. 3.

[10] Barrois, *Faune Calc. d'Erbray*, *Mem. Soc. Geol. Nord*, iii, 1889, p. 127 pl. viii, figs. 1, 1*a–f*.

Athyris [*Spirigera*] *undata* (Defrance).

1828. *Terebratula undata* Defrance, *Dict. sciences nat.*, vol. liii, p. 155.
? 1853 *Terebratula sculpta* Steininger, *Geogr. Beschr. Eifel.*, p. 68, t. vi, figs. 15, 16; t. xxix, fig. 7.
1855. *Terebratula undata* De Verneuil, *Bull. Soc. Geol. France*, ser. II, vol. xii, p. 1008, pl. xxix, fig. 7.
1855. *Spirigera undata* Sandberger, *Sitzungsber. k. k. Akad. Wiss. Wien*, Kl. Nat., Bd. xviii, p. 116, t. i, figs. 10, 11.
1878. *Athyris undata* Bayle, *Explic. Carte geol. France*, Atlas, pl. xii, figs. 1–14.
1885. *Athyris undata* Oehlert, *Ann. Sc. géol.* xix, art. 1, p. 32, pl. iii, fig. 1–20.
1889. *Athyris undata* Kayser, *Abh. k. preuss. geol. Landesanst.*, N.F., i, p. 38, t. iii, figs. 1–6; t. i., fig. 1; t. xvii, figs. 1, 2.
1915. *Spirigera undata* Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxix, p. 27, t. vii, figs. 4–7.

Good internal casts showing all the characteristic features of this species occur in the Kilmorie Beds, some of which show the muscle-scars extremely well. One specimen has a length of 32 mm. and a width of 44 mm. Upfield Green[1] has recorded this species from the Gedinnian of Cornwall. The species is restricted to the Lower Devonian.[2] The species *A. avirostris* Krantz,[3] is scarcely separable from it, and the same may be said of *A. rauffi* Assmann.[4]

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 33, 44, 50).

Note.—Since the publication of Part I of these Notes on the Fauna of the Lower Devonian Beds of Torquay (Geol. Mag., Vol. LVII, 1920, pp. 299–306, 341–7, Pl. IV) my attention has been drawn to the fact that after an examination of the types Rudolf Richter (*Jahrb. k. preuss. geol. Landesanst.*, Bd. xxxvii, i, Heft 2, 1916, pp. 250–2, t. xxv, xxvi) has been led to consider that the original *Cryphæus laciniatus* F. Roemer is a synonym for *Cr. rotundifrons* Emmrich, and that Kayser's *Cr. Lethææ* is divisible into two distinct species, *Cr. Lethææ* sens. str. and a new one *Cr. Kochi* Richter (op. cit., t. xxv, figs. 6–9; t. xxvi, figs. 1–6).—F. R. C. R., May, 1921.

An Outline of Chinese Geology.

By J. S. Lee, M.Sc., Birmingham.

(*Continued from p. 265.*)

(WITH PLATE VI).

The Wutai-Nankou Systems.

When Richthofen journeyed in the Wutai district, Shan-si, he found a mighty sequence of metamorphosed sedimentary strata[5] which could not be classed as his Sinian or any series

[1] Upfield Green, Geol. Mag., Dec. V, Vol. I, 1904, p. 406.
[2] Bedard, *Bul. Soc. belge Geol. Pal. Hydr.*, vol. i, 1887, p. 83.
[3] Drevermann, *Palæontographica*, Bd. l, 1904, p. 256, t. xxx, figs. 13–18.
[4] Assmann, *Jahrb. k. preuss. geol Landesanst.*, xxxi, i, 1910, p. 153, t. xi, figs. 1–5.
[5] *China*, vol. ii, p. 367.

younger than the Sinian, nor could it be regarded as belonging to the Old Gneiss and Gneiss-granite group. They are apparently equivalent to similar strata occurring in eastern Shan-tung and Liao-tung.[1] In descending the Wutai-shan along its southern flank, Richthofen first came across a thick series of green schists with alternating beds of grey slates and quartzites, and then several series of coarse quartzitic and felspathic well-stratified rocks, aggregating to a thickness of more than 5,900 feet. He calls the whole sequence of these strata the "Wutai Formation", and parallels it with the Huronian. This term at once found a wide application in Chinese geology. Thus in the western Tsing-ling Range, south of Lio-yang-hsien (about long. 106° E., lat. 33° 25′ N.), and in the high mountains west of Ta-tsien-lu (about long. 102° 10′ E., lat. 30° N.), Loczy distinguishes a series of highly metamorphosed sedimentary rocks, such as gneiss, schists, phyllites, crystalline limestone, etc.,[2] and assigns it to the Wutai Formation. The "Nan-shan Sandstone"—a series of unfossiliferous grey and green sandstones with well-cleaved or even schistose clayslates, typically developed in the northern foothills of the Nan-shan Ranges—is also tentatively regarded by the same author as a Wutai Formation. Between Ping-liang and Men-chou, in the province of Kan-su, Futterer identified in several places the Nan-shan Sandstone, and found other metamorphosed sedimentary strata of the Wutai Formation, consisting of chlorite-schist, coarse-grained quartzite, slate, and graywacke. In all these cases the term Wutai evidently implies the analogy with the Algonkian of North America.

As the result of field observations in the adjoining area of Shan-si and Chi-li,[3] particularly in the Wutai district, Willis and Blackwelder were able to recognize two systems of rocks of pre-Cambrian age: the lower or the Wutai System rests unconformably upon the Tai-shan Complex, and the upper or the Nankou (Huto) System is believed by the same authors to overlie unconformably the Wutai System. They further state that the unconformable junction between the Huto and the Wutai may be seen on the top of the Nantai-shan. This statement has been, however, not yet confirmed by published reports of field observation in the Wutai district. What may be regarded as a case supporting this inferred stratigraphical relation is a photograph in the *Record of the Work of the Geological Institute*, showing the Nankou (Huto) System resting unconformably on the Wutai strata in the Chien-an district, north-eastern Chi-li.

The Wutai System is well developed in the south-eastern flank of the Wutai-shan. Willis and Blackwelder divide it into three series in the following descending order:—

[1] *China*, vol. ii, pp. 106, 107, 215–17.
[2] Loczy, op. cit., vol. i, pp. 428–65, 692–726.
[3] Willis, op. cit., vol. i, pt. i, pp. 99–135.

c. Sitai Series. A thick series of monotonous, fine-grained chlorite-schists grading downwards into a basal conglomerate, which latter contains such pebbles "as the underlying Nantai Series would furnish".

b. Nantai Series. Largely consists of dark quartzite and siliceous marble with a subordinate amount of schist; the total thickness is probably less than 2,000 feet.

a. Shitsui Series. Stratified schists, gneiss, and schistose quartzite predominate in this series. The apparent thickness is estimated at 12,000 feet; but the real thickness may not be more than 6,500 feet.

According to Willis and Blackwelder, the Huto System is exposed in the Tou-tsun, Liu-yuan, Tung-yu districts, near the Wutai-shan, and in the northern slope of the Ki-chou-shan (about long. 113° E., lat. 38° 30′ N.). It consists of two series:—

Upper. Tung-yu Limestone. Limestones with subordinate slates; the former sometimes contain beds of quartzite, and sometimes layers of flints; total thickness 3,500–5,000 feet.

Lower. Tou-tsun Slate. Grey phyllite or slate with occasional thin layers of limestone or dolomite; total thickness 3,000 feet or more.

In the same area the above-mentioned authors distinguish a third formation of limestone, the Ta-yang Limestone, containing numerous characteristic layers of flints and occasional beds of quartzite. With good reason they assign the Ta-yang Limestone to the Nankou (Huto) System. From lithological similarity and from the parallelism of stratigraphical sequence, Willis correlates the Ta-yang Limestone and other Huto rocks with the series of flinty limestone of Nankou, north-western Chi-li, and of the Hwei-lu district, south-western Chi-li, that underlies the fossiliferous Cambrian. He therefore proposes to replace the term Huto System by the term Nankou System when the equivalency of the two is eventually established.

Although rocks of approximate Algonkian age in Chi-li and north-eastern Shan-si permit of a twofold grouping the application of this classification outside this area is problematical. Pending further research, a collective name would be useful for denoting those rocks found in all parts of China that are equivalent to a part or the whole of the Wutai and the Nankou (Huto) Systems. For this purpose we may conveniently use a united term, the Wutai-Nankou Systems.

The Wutai-Nankou Systems thus defined would include, in addition to the rocks so far mentioned, the chlorite-schist, biotite-schist, crystalline limestone, slates, quartzite, and other highly altered sedimentary strata in the eastern and middle Tsing-ling Range; a part of the highly metamorphosed strata in the north-western Nan-shan Ranges, namely, on the southern side of the Tolai-shan, in the Da-ssue-shan, the Ritter Mountain, and the Muschketov Range; the "pre-Cambrain" quartzite and quartzose phyllite with green grits exposed between Kwei-lin and the Si-kiang, in the province of Kwei-chou, and other "pre-Cambrain" rocks that occur to the west of Kien-kiang, in the

vicinity of Ta-li (Yun-nan), and in the "Zone of Hou-kouang Flexure" (Kwang-si)[1]; the crystalline phyllite observed by Mr. V. K. Ting in the Tchu-ning district, Yun-nan. The quartz-rock exposed in the neighbourhood of Hong-kong, the schist that occurs in association with granite in the Isle of Hai-nan,[2] and finally the Kao-liang Series[3] of the Teng-yue district as mentioned by J. C. Brown, should perhaps be attributed to these Systems.

As will be seen from the above sketch, China, particularly Northern China, is one of the few countries that offer good opportunity for the study of pre-Cambrian geology. Unfortunately, neither the scope of this paper nor the state of our present knowledge permit us to discuss the geological processes that were operative as the earliest geological era dawned in that part of the globe; and any such attempt would inevitably involve us in the old conflicts between different schools of uniformitarians. That the basal stratum of the Wutai System was originally formed under water is, however, an unquestionable fact. The Wutai Sea, which presumably covered parts of north-east China during the early stage of the Wutai period, became fairly deep towards the middle of the same period, or the Nantai epoch. During the latter part of the Wutai period, or the Sitai epoch, a wide ocean extended over large areas of northern China, and received strikingly uniform clayey material from all the surrounding lands. Even the northern Tsing-ling area that had evidently stood above the Nantai water, was by this time submerged under the Sitai sea; as evidence Richthofen and Willis have independently and definitely identified the chlorite-schist of the Sitai Series in the eastern and the middle Tsing-ling Range.

An orogenic movement of far-reaching character took place in Northern China at the end of the Wutai period. The rocks formed during the Wutai period were thus severely deformed and dynamically metamorphosed. Large bosses of granite and syenite with their accompanying offshoots and differentiated dykes, were injected into the Tai-shan Complex and the Wutai strata, such as those found in eastern Shan-tung, north-eastern Shan-si, and western Hu-peh. The advanced phase of metamorphism usually exhibited by the Wutai rocks in contra-distinction to the slightly altered state of the overlying Nankou or Huto Formation, speaks for the intensity of the stress and strain that the Wutai rocks must have gone through before the formation of the Nankou rocks had begun. The principal attack of the movement seems to have come from the south-east, for it has impressed a north-easterly strike on the rocks affected.

As this great disturbance gradually died out, the area of Shan-si and Chi-li began to subside. The Nankou period thus set in. If

[1] Leclère, op. cit., pp. 21–2.

[2] Madrolle, "Étude sur l'isle d'Hainan": *Bull. Soc. geogr. Paris*, sér. VII, vol. xix, pp. 187–228.

[3] *Record Geol. Surv. India*, vol. xliii, p. 188, pl. iii.

the chemical composition of the pre-Cambrian rocks signifies certain physical conditions of the sea in which they were formed in such a way as it does in the case of post-Cambrian deposits, then we may take the fact that the Nankou Formation changes its lithological character from argillaceous to calcareous towards its upper part in the area of Chi-li and Shan-si, as being indicative of a persistent lowering of the sea-floor. Nevertheless, in western Shan-tung, apart from the occasional presence of a few thin beds of a flinty limestone, which may be doubtfully regarded as the latest stage of the Nankou Formation, we know no rocks equivalent to the Nankou System of Chi-li. What are supposed to be the representatives of the Wutai System there are schists and quartzites which nowhere attain a great thickness, and are frequently absent. These facts converge to show that practically during the whole of the Nankou period western Shan-tung was subjected to subaerial denudation. The Tsing-ling area is likewise reported to be free from sediment belonging to the Nankou System.

The continued subsidence of the sea-floor in Chi-li and Shan-si appears to have been accompanied by a gradual and uniform elevation of the neighbouring lands, enabling the eroding agencies to reduce north-east China to a vast peneplain of mature type. Elsewhere towards the close of the Nankou period the tranquil sedimentation was, however, punctuated by local earth movements. In the Tsing-ling area this movement may have reached to the magnitude of an orogenic upheaval. Igneous magma again intruded itself at several localities in northern China. They are essentially of basic composition, and relatively insignificant in number.

The Sinian or Cambro-Ordovician.

The term Sinian was first introduced by Pumpelly for expressing a system of north-east folds in Eastern Asia.[1] Richthofen during his exploration found a group of rocks, chiefly composed of limestones, spreading over large areas in north-east China where the Sinian folds prevail. He then termed the rocks the Sinian (Sinisch) Formation. The discovery of a "primordial fauna"[2] in the middle part of this mighty sequence of rocks led Richthofen to believe that the top of the Sinian chronologically extended into the Ordovician, and its base reached down, in some cases, to the pre-Cambrian.

An unconformity of great magnitude was subsequently discovered by Willis and Blackwelder within the Sinian System of Richthofen. The plane of the unconformity lies directly below a series of red shale and sandstone. They therefore found it desirable to shift the lower boundary of the Sinian System on to the plane of the said unconformity. The lower part of Richthofen's Sinian System, namely, the series of strata lying underneath the fossiliferous red

[1] Pumpelly, "Geological Researches in China, Japan, and Mongolia": *Smithsonian Contributions*, vol. xv, p. 67.

[2] Dames, *China*, vol. iv, pp. 1–33.

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MONGOLIA
NAN SHAN
KANSU
SHENSI
SHANSI
CHILI
LIAOTUNG
SHANTUNG
Tsing ling
HONAN
SUCHUAN
HUPEH
ANHUI
KIANGSU
CHEKIANG
KWEICHOW
HUNAN
KIANGSI
FUKIEN
YUNNAN
KWANGSI
KWANGTUNG
Kuku Nor
Semenow Mt.
Lanchow
Sining
Tsinan
Tsingtao
Hankow
Nanking
Shanghai
Ningpo
Changsha
Kweiyang
Yunnanfu
Canton
Hongkong
Lolo
A SKETCH-MAP OF
CHINA
SHOWING ITS
TECTONIC OUTLINES.
References:-
Strike of cleavage-plane and trend of fold or flexure
Fault or fracture.
Uncertain fault or fracture.
Provincial boundary

To face p. 320.]

series, is accordingly assigned to the older systems. It should be noted, however, that in the Nankou area, north-western Chi-li, the Nankou limestone appears to pass upwards into the Sinian without a notable break.[1] The upper boundary of the Sinian System is likewise well defined by a stratigraphical break of considerable vertical range and horizontal extent. Immediately above this plane of unconformity lies the coal-bearing Shansian System.

Throughout north-east China, namely, the area comprising the provinces of Shan-tung, Chi-li, Shan-si, and Ho-nan, the development of the Sinian System is wonderfully similar in lithology as well as in faunal record. Nowhere within the above-described area do the succession and the character of the three principal series of the Sinian differ to any extent from the following generalized section in descending order:—

c. Orthoceras Limestone. A massive, uniform limestone often dolomitic; containing few fossils excepting in one zone near the top of the series where whole beds are formed by *Orthoceras* and *Actinoceras*. *Asaphus*, *Maclurea*, and other Ordovician forms are rarely found.

The Tsinan Limestone of western Shan-tung and the upper Kichou Limestone of north-eastern Shan-si are local representatives of this series.

b. Globulitic Limestone. Series of peculiar oolitic, globulitic, or even pseudo-conglomeratic limestones with occasional intercalations of shale; crowded with Upper and Middle Cambrian fossils, particularly trilobitic remains; *Ptychaspis*, *Tsinania*, *Conokephalina*, *Anomocare*, *Anomocarella*, *Dorypyge*, *Ptychoparia*, *Drepanura*, *Agnostus*, etc., are among the well-known genera.[1]

In Liao-tung and western Shan-tung Richthofen names the upper part of this limestone the Lung-mönn Series and the lower part the Tung-wönn Series; Blackwelder calls them the Kiu-lung Group. In Shan-si it is represented by the lower part of the Kichou Limestone.

a. Manto Shale. Red and brown shales with subordinate sandstones and earthy limestones containing the characteristic species *Redlichia chinensis*, a form resembling *Olenellus*.

[1] *China*, vol. ii, p. 306.

(*To be concluded.*)

REVIEWS.

ECONOMIC MINERALOGY. By THOMAS CROOK, A.R.C.S., F.G.S., M.I.M.M. pp. xi + 492, with 247 figures. London : Longmans, Green & Co., 1921. 25*s.* net.

AS the author states in the preface this volume is intended for those especially interested in the utilitarian side of mineralogy, he therefore contents himself with one chapter on crystal symmetry instead of the usual detailed account of all possible crystal forms given in textbooks of mineralogy. As the economic mineralogist seldom meets with well-crystallized minerals, the writer thinks this is a justifiable curtailment.

The chapter on crystal optics is an unusually clear exposition of what is often a difficult subject to the student of mineralogy, and the same applies to the chapter on physical analysis, but the section dealing with flotation might have been improved if a simple apparatus for laboratory separation by flotation had been described.

Under the geology of mineral deposits the author gives a useful summary of the chief deposits of economic minerals arranged in order of age.

The detailed description of the individual minerals is clear and complete, and the lists of the chief occurrences of the minerals of each metal are much more complete and detailed than is usual.

In the description of the use of the Westphal balance, no details are given of the use of the instrument for the determination of the specific gravity of a mineral fragment, nor is there any mention of the use of the hydrometer for the determination of the density of a liquid which is certainly not often made use of in mineralogical work.

At the end of the volume is a series of tables, the first of which gives the minerals in order of hardness with their chief physical and chemical properties, and with the refractive index and birefringence of the minerals with non-metallic lustre. It would have been useful to add these last details in the case of the minerals with metallic lustre which are transparent under the microscope.

The last table gives the minerals grouped according to colour, but the fact of there being only six colour groups seriously affects its value as a help to determination.

The illustrations are excellent, the photographs in most cases being taken from specimens in the Natural History Museum.

E. H. DAVISON.

CHROMIUM ORE. By W. G. RUMBOLD. Imperial Institute Monographs on Mineral Resources. 58 pp., with 2 diagrams and a map. London : John Murray, 1921. Price 3*s.* 6*d.* net.

THE importance of chromium in the metallurgy of steel and the wide use of certain of its compounds in technology, have long been known, and the recent introduction of alloys of the stellite group

appears to offer a further field of usefulness. For some years past Southern Rhodesia and New Caledonia have been the largest producers, but war conditions led to a reversion by the Central Powers to old sources of supply in Asia Minor, while enormous development took place in the low-grade ores of the United States. This monograph contains a very complete account of the geological occurrence and exploitation of chromite, the only practicable ore of the metal, together with a summary of its technical treatment and uses. The employment of chromite as a refractory seems likely to extend in the future. The work follows the general plan of this now well-known series and includes useful tables and a bibliography.

THE LIFE OF HORACE BENEDICT DE SAUSSURE. By DOUGLAS W. FRESHFIELD, D.C.L., with the collaboration of HENRY F. MONTAGNIER. London: E. Arnold, 1920.

A REALLY good life of De Saussure in English has long been desired, and no one so competent as Dr. Freshfield could be found to undertake it. He began Alpine travel with his parents as a boy of 14, and after graduating at Oxford, visited Syria and Armenia, nearly reaching the summit of Ararat; climbed Kasbek and a peak of Elbruz; went over high passes and ascended peaks in the Caucasus; took a high-level route round Kanchenjunga; has visited mountain lands in Uganda and elsewhere, and can describe them admirably, as his many books show; and recently, through Mr. Montagnier, he has obtained access to many letters by De Saussure which were previously unknown. He has in short given us a singularly interesting book on a great pioneer in Alpine travel, and a man in other respects remarkable. De Saussure was born in 1740, a citizen of Geneva, a member of a rather wealthy family, and an exceptionally able man. Educated at the College and University of his native city, he paid his first visit to Chamonix in 1760, the glaciers of which, though Mont Blanc is in full view, may be said to have been discovered nineteen years earlier by Pococke and Windham, was appointed Professor of Physics and Metaphysics in 1763, discharged these rather opposite tasks with success; married two year later a wife who added much to his happiness and property, and in 1768 began a two years' journey in France, Holland, and Britain, during which he made many friends and was hospitably entertained by such men as Sir Joseph Banks and Lord Palmerston, father of the one better known; visited Stamford and Burghley, York, Knaresborough, Leeds—where he went down a coal-mine, Wynnstay, Wentworth Castle, Chatsworth, Manchester, caverns and mines in Derbyshire, and even travelled to Cornwall to inspect its mines, recrossing the Channel in the beginning of 1769. He had also visited the two Universities, met numerous men of eminence, and been welcomed everywhere.

But his records of his journeys, both at home and abroad, are unfortunately incomplete. His last Alpine journey was in 1792,

the concluding volume of the voyage four years later. By this time his health had failed. Notwithstanding his efforts, he had been carried into the political vortex, of which Geneva was a centre, and forced to take a leading part in politics. It was an epoch of revolutionary ferocity, such as that of which we have not yet seen the end. De Saussure was almost ruined, and his life more than once in imminent danger. Then he became an official, but a new evil was at hand. Early in 1794 he had a stroke of paralysis, after which his journeys were restricted to those in search of health. Two years afterwards the anarchists again broke loose, after which, notwithstanding the promises of Napoleon, Geneva became the *chef lieu* of a French Department. De Saussure did not long survive the Republic, which he had done his best to raise, for he passed away peacefully in his town house on 22nd January, 1799.

Except for a dyspeptic tendency, his health was good, he was capable of much endurance, and his intellectual vigour was remarkable. Repeatedly he anticipated the conclusion of other workers. The intellectual gap between his writings and those of Scheuchzer is remarkable. The two writers were separated by about half a century, but the *Itinera Alpina* abounds in stories of dragons lurking in caverns, flying through the air, or haunting Alpine recesses, while De Saussure writes as a man of science. On only one important matter does he go wrong. He failed to obtain a sound idea of glacier motion, and attributed moraines and perched blocks to great catastrophes and floods. But, excepting these, which, had health been maintained, he might have corrected, he surpassed all his predecessors, except Leonardo de Vinci.

SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN. pp. 70, 3 text-figures. 1919.

IT is highly satisfactory to find that with the return to more normal conditions generally the officers of the Geological Survey have been able to resume the work upon which they were engaged in pre-war days in the Montgomery-Shropshire district and the Warwickshire-Staffordshire district.

In the first of these districts the most interesting work accomplished would appear to be the completion of the mapping of the Ordovician rocks, the adoption of the terms Caradocian and Ashgillian for the upper members of the series, and the recognition of the advent of *Pentamerus* as indicative of the beginning of Silurian. In the Warwickshire-Staffordshire area important work relative to the demarcation of the Middle Coal Measures (Grey Productive Measures) has been carried out.

Notes relative to lead, zinc, and copper mines in various parts of the country are given, and the borings for oil in Derbyshire and Staffordshire are also reported on.

In Scotland the Highland work was resumed in the North and Central Highland district, and the revision of the coalfields continued.

Work in South Lanarkshire has resulted in considerable increase in knowledge concerning the important outlier of the Douglas Coalfield, and a valuable comparison made between the beds at Coalburn and Ponteigh illustrated by clear vertical sections of the rocks worked at the two places. Borings for oil have been made in many places in the coalfields and oil-shale fields, the most interesting being the search for the extension of the Linlithgowshire oil-shales in a north-west direction, without success. The important and interesting details relative to the alternative of these oil shales are made the subject of a special appendix, illustrated with three admirable vertical sections.

As usual the appendices contain details relative to matters of special economic import; of these which are five in number, three relate to coalfields and two to Mesozoic rocks.

G. L. E.

Fossil Bird-remains collected by Dr. Forsyth Major in Sardinia, Corsica, and Greece. By E. T. Newton. Proc. Zool. Soc. April, 1921.

DR. FORSYTH MAJOR has for many years been interested in collecting fossil vertebrate remains from caves in Sardinia and Corsica, and several years ago some interesting bones of birds from among these fossils were described by Mr. R. Lydekker. Since then further extensive explorations in these and several other caves have yielded many more remains of both mammals and birds. We are still waiting for Dr. Forsyth Major's description of the former, but the Avian bones are briefly described in the present paper by E. T. Newton. A few additional species are noted from the three caves which yielded Mr. Lydekker's specimens. Several other caves have also yielded birds' bones, but by far the greater number are from the Grotta di Funtanedu, near Basta, N.E. Corsica, which is said to be 400 metres above the sea. A list of some thirty-four species is given from this cave, but each is represented by only a few bones. All the forms identified are referred with more or less certainty to living species, but a few of them seem not to have been previously recorded from these Mediterranean islands. Although the Avian species recognized give no clue to the geological horizon of the deposits in these caves, Dr. Forsyth Major has reasons for regarding them with one exception as of Pleistocene Age.

REPORTS AND PROCEEDINGS.

Geologists' Association.

3rd June, 1921.

"The Geology of Belgium, with special reference to the Long Excursion." By L. Dudley Stamp, M.Sc., A.K.C., F.G.S.

Natural regions and physical geography of the country. The northern lowlands, the long narrow Namur Coalfield, the southern

uplands (Ardennes). Relation of topography to geological structure; the northern lowlands a Palæozoic platform covered by Cretaceous and Tertiary; the Namur Basin a Devono-Carboniferous synclinorium; the Ardennes also a Devono-Carboniferous synclinorium with a Silurian ridge on the north and Cambrian "massifs" on the south. Geological history of the country; pre-Devonian rocks; the great Devonian transgression. The late Carboniferous (Armorican or Hercynian) folding. The Ardennes—London ridge and its influence on Mesozoic and Tertiary stratigraphy. The Cretaceous transgression. The Anglo-Franco-Belgian Basin of Eocene times. Pliocene: Diestian and Lenham Beds. Tectonics — three great epochs of folding; late Silurian, late Carboniferous (Armorican), Cretacco-Tertiary (Alpine). The Brabant stable block and its influence on Armorican folding. Some notes on the districts to be visited.

"Possible causes of Mountain Folding." By A. J. Bull, M.Sc., F.Inst.P., F.G.S.

Salient features of the earth's crust, the lines of folded mountains bordered by large regions of no compression. Occasional evidence of tension. Fjords. Fissure eruptions.

Explanations of folding by (*a*) the assumption that the earth is cooling, (*b*) periodic contraction of the earth due to molecular rearrangement, (*c*) penetration of oceanic water into the crust, (*d*) loading of the crust by terrigenous deposits and other hypotheses. Difficulties of accepting some of these explanations.

Other factors to be considered. Radio-active content of rocks. Isostatic adjustment. Strength of the crust. Crustal tides. Probable condition of the earth's interior. Heterogeneous composition of crust. Suggested explanation of folding as being due to underdrag of crust by convective currents in the asthenosphere, produced by local heating and expansion, enhanced possibly by changes of crystalline form in the cooler parts.

OBITUARY.

M. Rene Fourtau.

By the death of M. René Fourtau, palæontological science has sustained a severe, and in some respects, irreparable loss. Born on 26th February, 1867, he was mainly educated at the College of St. Caprais, Agen. He came to Egypt in 1888, and was associated with the railway administration for some years, being for a while in control of boring operations undertaken in the Delta in connexion with bridge construction. He early became interested in the problems of Egyptian geology, and came into contact with leading palæontological authorities, such as M. de Loriol.

When the Geological Survey of Egypt was founded in 1896,

M. Fourtau at first adopted a somewhat critical attitude. As he became acquainted with those who formed its staff, he realized that they were as keenly interested in geological study as he was himself, and this led first to mutual recognition and then fuller co-operation. Acting on a suggestion made by one of the authorities at the Natural History Museum, the collection of sea-urchins in the Cairo Geological Museum was submitted to him for identification and study. The satisfactory results obtained led to his being given the rearrangement of the fossil collections at the Museum, and finally to his appointment as Palæontologist to the Geological Survey of Egypt. Here he proved a most helpful colleague, examining the rich collections which the Petroleum Research parties sent in from the field, and promptly sending them the results. The catalogues of the Invertebrates in the Cairo Geological Museum, published during this period, and illustrated by the well-known artist, M. Gauthier, of Sens, remain a permanent monument to his industry and scientific acumen.

In 1916 he entered the field of vertebrate palæontology under interesting circumstances.

The Denbighshire Yeomanry were camped at Moghara, 80 miles south-west of Alexandria, a locality already well known to geologists as an important source of Miocene fossil vertebrates. It was not long before the officers and men discovered these relics of the past, and were greatly puzzled at their presence in so arid a waste. A large crocodile skull was sent to the Cairo Geological Museum, and as a result the writer went to Moghara and explained the nature of the occurrence to the troops. It was also arranged with Col. Lloyd, the officer commanding, for the collections to be housed at the Geological Museum pending decisions as to their final destination, and M. Fourtau was deputed both to secure their safe transport, and make further examinations of the exposures. It was also decided that he should issue a description of the collections while they were still assembled at one spot, the result being the interesting memoir (Contribution à l'Étude des Vertébrés Miocènes de l'Égypte, Cairo, 1918), of which advance copies were issued during the war.

Fourtau also carried out several other important fossil collecting expeditions as part of his duties, these including visits to the Wadi Natrun and a closer examination of the region of North Sinai, made notable by M. Barthoux' discovery of Jurassic strata.

Special leave had been granted him to enable him to study the palæontological results, in Europe, Professors de Stifani and Stefanini placing working rooms at his disposal for this purpose in the Istituto Superiore di Geologia of Florence. He had scarcely commenced his work there before he fell ill, his death occurring on 2nd November, 1920.

Fourtau was gifted with a remarakble memory, and great powers or work. His enthusiasm brought him in close touch with a number of earnest workers in his own branch of science. He has left behind him two memoirs dealing with the North Sinai sea-urchins, which it